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MEMOIRS OF THE GEOLOGICAL SURVEY,
SCOTLAND.

ENGI STORAGE

SPECIAL REPORTS ON THE MINERAL
RESOURCES OF GREAT BRITAIN.

VOL. XI. IRON ORES (*continued*)



THE IRON ORES OF SCOTLAND.

BY

M. MACGREGOR, B.Sc.; G. W. LEE, D.Sc.; G. V. WILSON, B.Sc.

WITH CONTRIBUTIONS BY

T. ROBERTSON, B.Sc., AND J. S. FLETT, F.R.S.

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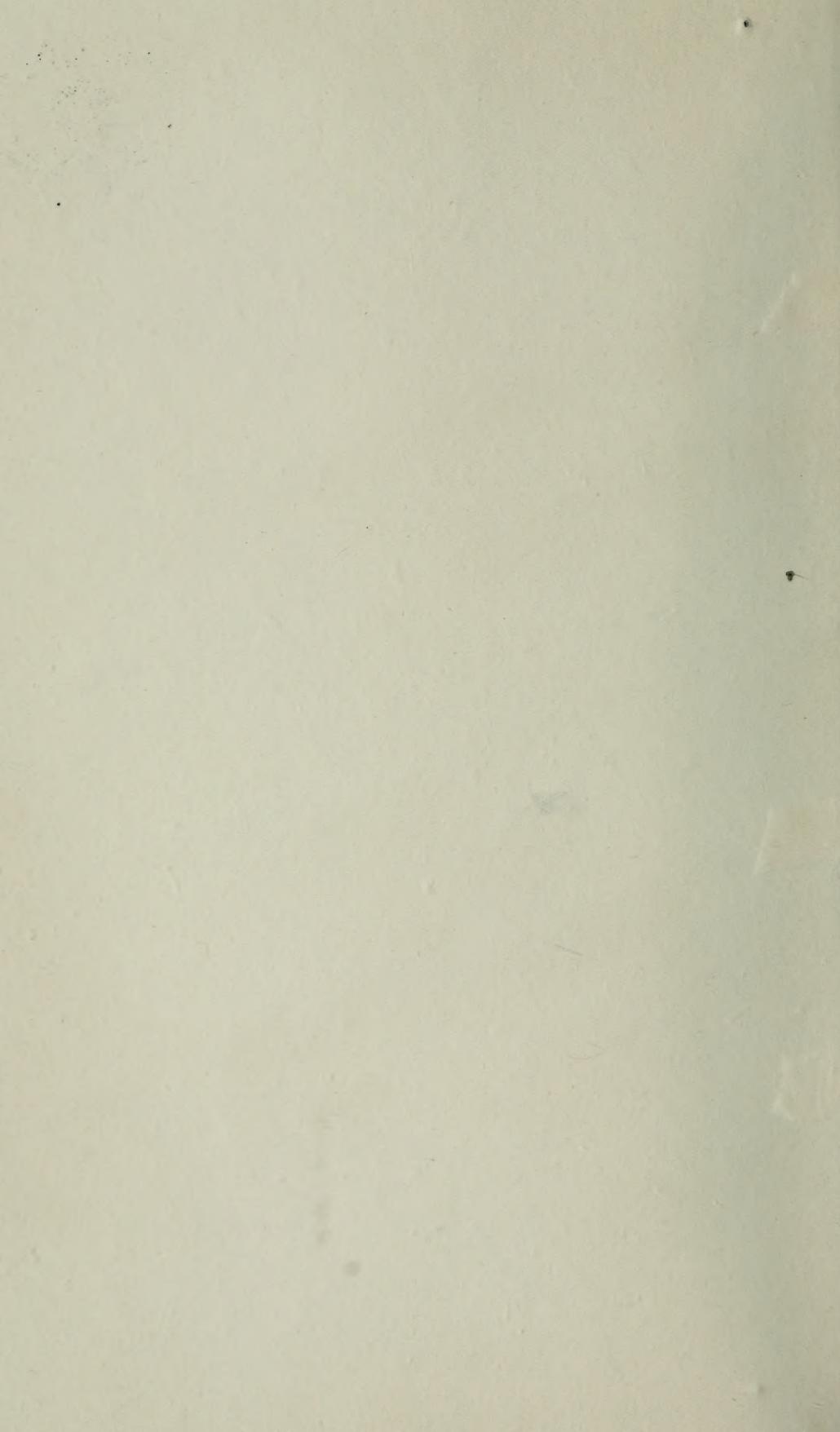


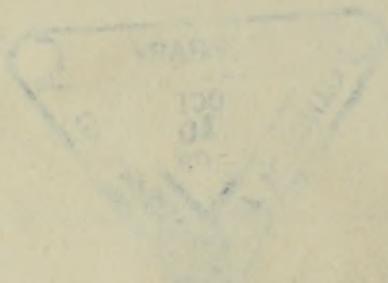
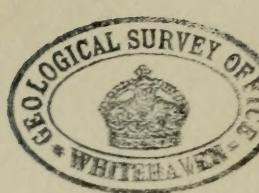
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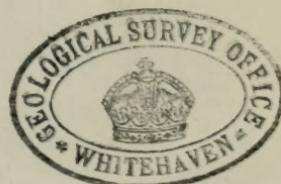
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PREFACE.

THIS Volume, the eleventh of the "Special Reports on the Mineral Resources of Great Britain" and the fourth of those reports devoted to the subject of iron ores, gives an account of all Scottish sources of ore. The most important source, by reason of the scale of the workings, the wide distribution and the magnitude of the reserves, lies in the blackbands and clay-ironstones which are associated with the coal-bearing strata in the Lower Carboniferous rocks and the Coal Measures. Haematites, though probably the first to be worked, are not abundant and ceased to receive attention some years ago. An occurrence of a Mesozoic bedded ore in Raasay, to which attention was drawn by the late H. B. Woodward in 1893, as a result of his survey of the Jurassic strata of the island, has recently been systematically explored on commercial lines and holds out promise of considerable development.

The information on these Scottish ores has hitherto been scattered through a number of Geological Survey publications, Home Office Reports, various books and communications to Scientific Societies. All these sources have been carefully investigated, such plans of iron mines, active or inactive, as were available have been examined, and several thousand records of borings, preserved in the Geological Survey Office in Edinburgh, have been consulted.

The estimates of available resources are in all cases conservative, and where information proved to be meagre, care has been taken to avoid a too hopeful view of the possibilities. In distinguishing between probable and possible reserves, the conditions under which the industry has hitherto existed in Scotland has been taken into account.

To many iron-masters, colliery officials, mining engineers, and others, we are indebted for assistance. Permission to consult plans and bores was freely granted, and in several cases special analyses have been made of specimens supplied by us, by the chemists of Scottish blast-furnaces. Individual acknowledgment of assistance rendered is made in the appropriate places in the volume.

The Memoir has been edited by Mr. M. Macgregor.

A. STRAHAN,
Director.

GEOLOGICAL SURVEY OFFICE,
28 JERMYN STREET, LONDON, S.W. 1,
31st January 1919.

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GLOSSARY OF SCOTTISH MINING TERMS USED IN THIS VOLUME.

Band.—A thin seam or stratum, e.g. clayband.

Balls or Ball Ironstone.—Nodular concretions of clayband ironstone.

Blacks.—Coaly blaes.

Blaes.—Fine-grained argillaceous sediments or mudstones, laminated but typically soft and non-fissile. So named from their dark-blue colour. They correspond roughly to the more general geological term "shales," a word which in Scotland is now generally reserved for those which yield oil on distillation. Varieties are *shaly* or *slaty blaes* (where firm and fissile); *fireclay blaes* (where bedding is obscure); *faky blaes* (where interbedded with more sandy material); *coaly blaes*, etc.

Blind Coal.—A coal which has lost part of its volatile constituents, and so burns with little or no smoke.

Bonnets.—Applied to gas coal or shale overlying and sometimes worked along with a coal.

Brushing.—That part of the roof of a seam removed to form roadways.

Cannel (i.e. Candle) Coal.—Typically a tough lustreless coal, breaking with a conchoidal fracture and having a high proportion of volatile hydrocarbons.

Cherry Coal.—A freely burning non-caking coal giving a bright flame.

Craw or Crow Coal, Craws.—Applied to a seam of inferior coal.

Daugh.—Soft, often black fireclay where found above, below, or as a parting in, a coal seam; the holing (*q.v.*) is often made in it.

Doggers.—Irregularly-shaped nodules or concretions. *Dogger* sometimes used for inferior ironstone.

Dross Coal.—Small coal; or often used to distinguish ordinary coal from cannel in compound seams.

Fakes.—Thin-bedded argillaceous sandstone or sandy blaes; passing through *faky sandstone* into sandstone and through *faky blaes* into blaes.

Falling (or Following).—That part of the roof which falls or comes down on the extraction of the seam beneath it.

Fireclay.—Somewhat loosely used for a non-laminated, often rooty argillaceous bed, generally an underseat. No special value as a refractory is necessarily implied.

Free Coal.—May mean easily broken or freely burning.

Holing.—The cutting made in, below or above a seam preliminary to working it.

Ingoing Eye (Ingaun 'ee).—The mouth of a drift or mine from the surface.

Kingle (Kennel).—A very hard, often limy sandstone; *ferruginous kingle*, a hard irony sandstone.

Lunker.—A lenticular mass or big nodule, e.g. of clayband.

Maggie.—Of inferior quality, cf. French *Maigre*. Applied originally as a noun to the blaes above an ironstone; also used to describe inferior sulphurous portions of an ironstone.

Mine.—A drift either from the surface (Ingoing Eye or Day Level) or from underground workings (Cross-cut, Stone Mine); not a pit.

Mussels.—Typically brackish-water lamellibranchs of the genera: *Cardincola*, *Anthracomya* and *Naiadites*.

Parrot Coal.—Similar to Cannel (*q.v.*); from crackling noise it makes on taking fire. Often associated with blackband ironstone, hence irony parrot, etc.

Pelt.—Coaly stone.

Ply.—A rib; *plies*—successive ribs, e.g. of clayband, with very thin partings.

Rhums.—Wild parrot; or locally, as in the Carboniferous Limestone districts of Fife, coaly blaes.

Rock.—Sandstone.

Selit (sclate, cf. slate).—Slaty coal or coaly blaes.

Slatyband.—A fissile ironstone consisting of alternating clayband and blackband laminæ.

Splint Coal.—A hard coal suitable for blast furnaces.

Waste.—Space left by extraction of a seam or the material used to fill it.

Whin, Whinstone.—A general name for any hard igneous rock; formerly loosely used for any hard rock.

Wild.—As applied to coal, blackband, shale, etc., means an irregular and inferior seam.

THE IRON ORES OF SCOTLAND.

CHAPTER I.

HISTORICAL NOTES, TABLES OF STATISTICS, AND SUMMARY OF RESERVES.

HISTORICAL NOTES.

THE iron ores of Scotland may be roughly classified as follows—

- (1) Bog ores of recent origin.
- (2) Haematite ores of different ages.
- (3) Carboniferous clayband ores.
- (4) Carboniferous blackband ores.
- (5) Jurassic ores.

This grouping expresses also in a general way the chronological order of their discovery. The bog iron ores are of interest chiefly from their use in the numerous bloomeries of early times. Iron manufacture on a small scale from ores of this type appears to have been carried on at local centres for many centuries after the Roman occupation of the country. Traces of this primitive industry are widely scattered, and the sites where they occur indicate a distinct evolution in the kind of furnace employed, from those built where some natural feature allowed advantage to be taken of the prevailing winds to those in which an artificial blast was produced by means of bellows or water. In the case of the haematite ores it is difficult to fix a definite date, but among the earliest records are those which refer to the working of the Pennel Burn haematite at Muirkirk about 1730, and of the Leicht Mine at Tomintoul by the York Buildings Company about 1736.* Carboniferous claybands, probably from the Fife coast, were apparently used to some slight extent in the Loch Maree furnaces (see p. 2) in the first half of the seventeenth century, but were first regularly worked in Scotland for the Carron Company at Bo'ness and elsewhere soon after its inception in 1759. Mushet's historic discovery of blackband ore in 1801 added largely to the home resources, although ores of this type did not come into general use until 1828. Finally, it is only within the last few years that the Jurassic ores of Raasay were discovered and their exploitation begun.

EARLY IRONWORKS.

Prior to 1759 (the year in which the Carron ironworks were founded) not much is known of iron-making in Scotland. The slag-

* For the Pennel Burn, see p. 209; for Tomintoul, p. 203.

heaps, which are found in many localities marking the sites of the small primitive furnaces known as bloomeries, are the only records left of the earlier phases of the industry. A long list of these has been compiled by Ivison Macadam,* and the subject has been dealt with by other authorities. Coming down to later times we have evidence of a group of furnaces of more advanced design in operation in the Loch Maree district during the first half of the seventeenth century. These furnaces were of the Catalan type, in which an artificial blast was produced by means of water, and castings were apparently made direct from the furnace itself. Much more complete, however, are the records of several furnaces set up in the Central and Western Highlands towards the middle of the eighteenth century. The sites of all of these were conditioned by the abundant local supply of wood for charcoal manufacture,† and to them must be attributed the present bleakness of some of the Highland valleys. Various authorities have apparently confused the later furnaces with one another, and the following notes may be of service to those who are interested in the history of the Scottish iron industry.

Loch Maree Furnaces (circa 1607–1677).—The group of furnaces in the Loch Maree district are apparently the oldest of which there is any definite record. They include those of Letterewe, Fasagh, and Red Smiddy. The first-mentioned was built probably about 1607 on the north bank of the Furnace Burn, where it enters Loch Maree, 1 mile south of Letterewe House (1-inch Sheet 92). Fasagh lay close to the loch on the south side of the Fasagh Burn (1-inch Sheet 92), while Red Smiddy, which is perhaps the most recent, was situated on the River Ewe, about a mile from its mouth (1-inch Sheet 91). They all seem to have been the scene of extensive operations, and their presence in the district has led to the belief that iron ores of considerable value must exist locally. The only deposits known, however, consist of comparatively small pans of bog iron ore. A good example of these pans formerly existed at South Erradale (1-inch Sheet 91), where a field wall was constructed of blocks taken from it. An analysis of two samples of the South Erradale ore, made by Ivison Macadam,‡ gave the following results:—

					Sample a.	Sample b.
Ferric Oxide	.	.	.	.	70·88	66·68
Metallic Iron	:	:	:	:	49·61	46·67
Silica	.	.	.	.	7·48	8·24

The pans of bog iron ore are not now either large or numerous, and it may be assumed that the bulk of the material was used up in the old furnaces or in the still earlier bloomeries which occupied the same sites. It is certain, however, that in the days of the Loch Maree furnaces imported ore was used, although we do not know to what extent. At Fasagh Macadam found only pieces of bog iron ore and fragments of the rich black slag derived from it, but at Letterewe and Red Smiddy both haematite and Carboniferous clayband have

* "The Ancient Iron Industry of Scotland," *Proc. Soc. of Antiquaries*, vol. xxi (1886), pp. 96–103, or *Trans. Inverness Scientific Soc.*, vol. iii. (1887), pp. 222–63.

† Peat charcoal was also used as fuel.

‡ *Ibid.*, where additional analyses are given of these bog ores, as well as of the haematite and clayband found at Furnace and Red Smiddy.

been discovered among the debris. The haematite was no doubt imported from Cumberland. Of the source of the clayband we know nothing, but probably it was brought from Fife and mixed with the haematite to produce a more fusible slag. It may be added here that the belt of rusty graphitic schists (forming part of the Loch Maree Series of the Geological Survey *) which extends from Furnace to Fasagh along the north-east side of Loch Maree, has been claimed locally as the source of the ore used. These schists contain, however, from 3 to 8 per cent. of iron only. There are, it is true, a few magnetite-bearing bands associated with them both here and elsewhere, † but all too thin to be regarded as potential ores. It is of some interest to note that the furnaces themselves were built of Torridon Sandstone.

Glenkinglas Furnace (? 1727—? 1731).—The Glenkinglas (or Glenkenlish) Furnace was situated on the east side of Loch Etive at the mouth of the Kinglas Burn (1-in. Sheet 45). The ruins are still visible. It is generally said to have been founded by an Irish company, but the year of its erection is not known. The records of the Invergarry Furnace contain, under the date 1727, the following item of expenditure :‡—

“ Paid Eneas McDonald, Founder, for coming from Glenkenlish to give his opinion of Bog and Rock Mine, £2, 2s.”

Fell § says of this furnace that in 1727 it was in the possession of the York Buildings Company, and was likely to have been in blast at the time of the building of the one at Invergarry. It appears to have been abandoned about 1731.

Abernethy Furnace, Strathspey (circa 1730—1737).—This furnace, built at Culnakyle, near Abernethy, was part of the ambitious project of York Buildings Company, who, in 1728, bought a large tract of the finest woods of Strathspey for the purpose of producing timber and charcoal on a large scale for export. The ironworks at Culnakyle included not only furnaces but also a “refinery,” where the pig iron was converted into bars. Part at least of the ore used came on pony-back across the hills from the Leicht Mine at Tomintoul (see p. 203)—a distance of about 16 miles. The whole scheme of operations, however, was soon abandoned.

Nether Wellwood, Muirkirk (circa 1730).—There are records of a furnace having been erected here, $\frac{3}{4}$ mile W.N.W. of Nether Wellwood House, about 1730, by one of the Earls of Cathcart, in order to smelt the haematite mined at Whitehaugh on the Pennel Burn. It was soon abandoned for lack of charcoal, and the ore sent by pack-horses to Ayr, and thence shipped to Bonawe.||

Owing to the difficulty of obtaining wood in England for charcoal manufacture, the wooded glens of the west coast of Scotland were a great attraction to the iron-makers of the Furness district. Vessels engaged in the coasting trade at this time (first half of the eighteenth

* Explanation of Sheet 92, *Mem. Geol. Surv.*, 1913, pp. 31–2, and 114.

† Cf. “Geological Structure of N.W. Highlands,” *Mem. Geol. Surv.*, 1907, p. 228.

‡ Fell, “Early Iron Industry of Furness” (1908), p. 353.

§ *Ibid.*, pp. 379–80.

|| J. G. A. Baird, “Muirkirk in Bygone Days” (1910), p. 44.

century) took away from such places as Bonawe charcoal, kelp, tanner's bark and salmon, and brought in exchange commodities like leather, stoneware, coals, etc. Several firms in the Furness district resolved to make the experiment of sending their ores to be smelted in Scotland where wood-charcoal could be readily obtained. In addition to the above there was thus an interchange of pig iron for raw ores. The following furnaces were built about this time:—

*Invergarry Furnace** (1729–1736).—This furnace lay on the south side of the River Garry, close to Loch Oich (1-in. Sheet 63), where John Macdonald of Invergarry granted to several Furness iron-masters permission to carry on the "Trade, Mistery, and Business of making Pigg Iron and Other Iron." All the structural materials of this furnace, in addition to the ore used, were sent from Cumberland to Corpach at the head of Loch Linne, and were thence conveyed no less than 22 miles up the Great Glen into the very heart of Scotland—a long, arduous, and at that time dangerous journey. The furnace was in existence for seven years, and was in blast for half that time. It produced 2450 tons of pig iron, which gives a weekly yield of 13 tons. The cost of the pig iron was naturally high, a ton of calcined ore costing over thirty shillings.

It is of interest to note that the records of this furnace show that attempts were made to find iron ore in various localities. Prospecting visits were paid to Islay, Jura, Fort Augustus and other places in search of "bog mine."

Lorne Furnace,† Bonawe (1753–1876).—This was the largest and most important of the charcoal furnaces in Scotland. It stood on Loch Etive, at the mouth of the River Awe (1-inch Sheet 45), and was established here by a group of Furness iron-makers who, by an agreement dated 30th September 1752, acquired a large tract of the Muckairn woods. The ore used was imported from Ulverston. On the expiry of the original lease in 1863 the Lorne furnace passed into the possession of Messrs. Harrison, Ainslie, & Co., iron-masters at Ulverston, and according to Fell continued working up to 1874. According to the list of blast furnaces given in the annual "Mineral Statistics of the United Kingdom" (*Geological Survey*) 1854–1883, the Lorne furnace was in blast in the years 1855–1858, 1863, 1868–1871, 1873–1876, and disappears from the list in 1882. In its early days the Lorne Furnace used also haematite mined at Whitehaugh, on the banks of the Pennel Burn.‡ A plan of the furnace, and a photograph of it as it appeared in 1912, is given in Mr. H. M. Cadell's "Story of the Firth."§

Goatfield Furnace (1775–1813).—This furnace, also known as Craeckan or Argyll, lay on the west side of Loch Fyne, 8 miles south of Inverary. Some writers give 1754 as the date of erection, but this is apparently an error due to confusion with the Lorne Furnace. The furnace itself bears the date 1775, nor was any ore sent from Ulverston to it before that year.|| It ceased working in 1813, and the buildings were afterwards used as a powder factory, which was wrecked by an explosion in 1885.

* For a complete account of this furnace see Fell, *op. cit.*, pp. 341–89.

† Fell, *op. cit.*, pp. 390–414, gives a full account of it.

‡ See "Muirkirk in Bygone Days," by J. G. A. Baird (1910), p. 44.

§ 1913, pp. 149–50.

|| Fell, *op. cit.*, p. 412.

LIST OF SCOTTISH IRONWORKS. 1760 TO PRESENT DAY.

Erected.	Ceased.	Name.	Situation.	Latest Owners.
1759-60	...	Caron.	Stirlingshire.	Caron Company.
1779-80	1842	Wilsonstown.	Lanarkshire.	Wm. Dixon of Calder Ironworks, from 1821.
c. 1786	...	Clyde.	Glasgow.	Jas. Dunlop & Co.
1787	1768(69) ⁽¹⁾	Omoa.	Lanarkshire.	R. Stewart's Trustees.
c. 1787	c. 1813	Glenbuck.	Ayrshire.	Said to be an English Co.
c. 1788	...	Muirkirk.	Ayrshire.	Wm. Baird & Co. Ltd.
c. 1792	1856(65)	Devon.	Clackmannan.	A. Christie.
1800-02	...	Calder.	Coatbridge (Lan.).	Wm. Dixon Ltd.
1801	Soon after	Balgonia.	Fife.	Messrs. Losh & Wilson, Newcastle.
1802	...	Shotts.	Lanarkshire.	Shotts Iron Co. Ltd.
c. 1825 ⁽²⁾	1887 (91)	Monkland ⁽³⁾ (or Calderbank).	Airdrie (Lan.).	Monkland Iron & Coal Co. Ltd.
1830	...	Gartsherrie.	Coatbridge (Lan.).	Wm. Baird & Co. Ltd.
1833	1868 (69)	Dundyvan.	Coatbridge (Lan.).	John Wilson's Trustees.
1836-37	...	Summerlee.	Coatbridge (Lan.).	Summerlee Iron & Steel Co. Ltd. (begun by Messrs. Neilson & Wilson).
1837	...	Govan.	Glasgow.	Wm. Dixon Ltd.
1837	...	Coltness.	Newmains (Lan.).	Coltness Iron Co. Ltd.
c. 1839	1884 (88)	Castlehill.	Carlisle (Lan.).	Shotts Iron Co. Ltd.
c. 1840	...	Carnbroe.	Coatbridge (Lan.).	Merry & Cuninghame Ltd. (begun by Allison & Co.).
1841	...	Langloan.	Coatbridge (Lan.).	Langloan Iron & Chemical Co. Ltd.
?	1854 (60)	New Cumnock.	Ayrshire.	New Cumnock Iron Co.
c. 1840	1870	Blair.	Dalry (Ayrshire).	Wm. Baird & Co. Ltd.
c. 1843	...	Glengarnock.	Ayrshire.	D. Colville & Sons Ltd. (Glengarnock I. & S. Co. previous to 1914).
1845-47	...	Dalmellington.	Ayrshire.	Dalmellington Iron Co. Ltd.
c. 1850	...	Ardeer.	Stevenston (Ayrsh.).	Merry & Cuninghame Ltd.
c. 1847	...	Eglinton.	Kilwinning (Ayrsh.).	Wm. Baird & Co. Ltd.
1847	...	Lugar.	Cumnock (Ayrshire).	Wm. Baird & Co. Ltd.
c. 1850	1890 (94)	Portland.	Kilmarnock (Ayrsh.).	Wm. Baird & Co. Ltd.
1846 ⁽⁴⁾	1869	Oakley or Forth.	Fife.	Forth Iron Co.
c. 1850 ⁽⁴⁾	1875 (96)	Lochgelly.	Fife.	Lochgelly Iron & Coal Co. Ltd.
c. 1850 ⁽⁴⁾	1874 ⁽⁵⁾ (1903)	Lumphunans.	Cowdenbeath (Fife).	Fife Coal Co. Ltd. from 1896 (Lumphunnans Iron Co. originally).
1853 ⁽⁶⁾	1884 (94)	Kinneil.	Bo'ness (Linlithgowshire).	Kinneil Iron & Coal Co. Ltd. (Geo. Wilson & Co. previously).
c. 1854	1881 (88)	Almond or Causeyend.	Falkirk (Linlithgowshire).	J. Russell & Son.
c. 1840-3	1854 (60)	Garscube.	Glasgow.	Montgomerie & Fleming.
? c. 1854	1871	Gladsmuir.	Ha'ldingtonshire.	C. & A. Christie.
1859	...	Wishaw.	Lanarkshire.	Glasgow Iron & Steel Co. Ltd.
1865	1887 (1900)	Quarter.	Hamilton (Lanarkshire).	Colin Dunlop & Co.
1863 ⁽⁷⁾	1873 (88)	Bridgeness.	Linlithgowshire.	H. Cadell.

In addition, the charcoal furnaces at Goatfield and Lorne were in operation up to 1813 and 1876 respectively.

Notes on previous Table.

- (1) Where two dates are given in this column, the first signifies the last year in blast, and the second, in brackets, the year when the furnaces ceased to be recorded in the annual lists. See "Mineral Statistics" (*Memoirs of the Geological Survey*) and Home Office Annual Reports: Mines and Quarries.
- (2) "Statistical Account of Scotland," vol. vi., 1845, p. 161; Day in "Leading Industries of Glasgow," 1876, gives 1805 as date of erection.
- (3) Monkland Ironworks here includes Calderbank and Chapelhall; these are first given separately in "Mineral Statistics" for 1879. Chapelhall was last in blast in 1886, Calderbank in 1887.
- (4) Cadell, "Story of the Forth," 1913, p. 192.
- (5) Again in blast 1883-4.
- (6) Cadell, *loc. cit.* Meade, "Coal and Iron Industries," 1882, p. 737, gives Kinneil in list of blast furnaces in operation in 1848, but not in corresponding list for 1843.
- (7) Cadell, *loc. cit.* Bridgeness first appears in 1871 in the annual list of blast furnaces given in "Mineral Statistics" (*Mem. Geol. Surv.*).

PERIOD 1760-1830. RISE OF THE CLAYBAND INDUSTRY.

The Carron Ironworks began their long career on the 1st of January 1760, a year which in many respects is the most significant in the history of the Scottish iron industry. It marks the transition from the small charcoal furnaces erected where wood was plentiful and dependent on imported Cumberland haematite, to the larger iron-works using coal to smelt local clayband ores. At Carron, the Carboniferous claybands were first regularly made use of, and at Carron, too, coal was first used to smelt them.* It was in the early days of Carron that Smeaton built his first cast iron blowing-cylinder, which replaced the leather bellows hitherto employed. In 1765 Watt's first engine was erected to wind coal at the Burn Pit, Bo'ness, owned by Dr. Roebuck, one of the founders of the Carron Company, and the later improvements of the inventor had in a few years adapted it to drive machinery of all kinds.

These years are marked by the rise and development of the clayband-mining industry. Along with the discovery of fresh deposits of this type of ore came the need for greater facilities to smelt it. An additional incentive was the increasing cost of importing Swedish and Russian iron. It would not be possible to give a full list of the localities and geological horizons from which the early ironworks drew their supplies of ironstone. These were chiefly of the nature of ribs or balls of clayband collected at outcrop workings along stream or shore sections, or derived from the roofs of worked coals. Any conveniently situated exposures of "blaes" or shales containing such ores was apparently considered worthy of exploitation in those early days when only small supplies could be dealt with. A list of the ironstones used at Carron in 1768, along with their yield in iron on roasting, is given by Musket in his "Papers on Iron and Steel" (1840, p. 117), and additional references are to be found scattered through the old and new Statistical Accounts of Scotland. The

* H. M. Cadell, "The Story of the Forth," 1913, p. 147; St. John V. Day in "Leading Industries of Glasgow" (published for the British Association meeting), Glasgow (1876), p. 32.

first ore to be smelted at Carron came from Bo'ness, and this locality heads Mushet's list. Among the other ores mentioned are :—

- Brighton (Polmont; probably the Ball Ironstone; see p. 118).
- Bonnyhill (Falkirk; probably the Hightstone; see p. 118).
- Bonnyhill Ballstone (Falkirk; probably the Lowstone; see p. 116).
- Kennaird (Larbert; probably balls above the Coxrod Coal).
- Castlerankie (Denny; probably the Black Metal Claybands; see p. 99).
- Dysart Balls (Fife; probably Lower Dysart Ironstones; see p. 160).
- Pitfirrane (Dunfermline; roof of the 2-ft. Coal; see p. 140).
- Stonehaven (perhaps the beds described on page 215).
- Orkney Ore (see p. 217).
- Cumberland Ore.

The Banton Claybands at Banton were worked at an early date; in 1767 Mr. William Cadell purchased the estate of Banton, which he soon after leased to the Carron Co.* Another early source of ore was found in the septarian nodules obtained at Westside and Burnhead in the Kilsyth district. From the old "Statistical Account of Scotland" (1792),† we know that the limestone here (Hurlet Limestone) was extensively worked even before that year and burnt in kilns. The ironstone nodules were obtained from a thick post of blaes not far above the limestone, and were collected and sent to Carron. Clayband balls were also collected for Carron at a later date at various places along the Forth, e.g. at Granton Harbour,‡ and at Gullane Point.§

The ironworks at Wilsontown (originally Forkens) drew their earliest supplies from the Hogg Fence Ironstones (see p. 102), mined in the Mouse Water and the Mosshat Burn, and later from the Curdly and Ginstone ironstones of the Levenseat district, etc. Among the ores used at Clyde were claybands from Crossbasket (High Blantyre), Calderwood (East Kilbride), Glazert and Shiel Glen (Lennoxtown), and other sources. Glenbuck and Muirkirk obtained their ore in part from the Pennel Burn haematite mines, in part from the local clayband ironstones, and the latter were even from the first probably the chief source of supply. At Devon, where the furnaces, enginehouse, and air-chambers were actually cut out of solid rock,¶ the clayband ribs from the roof of the 9-ft. Coal of Clackmannan, similar ores from the Tillicoultry-Dollar field, and an ironstone found in the Millstone Grit at Vicar's Bridge, were all smelted. Calder Ironworks used, among other ores, a musselband ironstone and a Ball-ironstone mined on Woodhall.** Omoa works smelted the clayband seam from the roof of the Cleland Wee Coal (Roughband Ironstone), and Shotts made use of the nodular layer found above the Furnace or Ball Coal of that district.

PERIOD 1830-1860. RISE OF THE BLACKBAND INDUSTRY.

This period is marked out by the intensive development of the blackband ores of Scotland, and was ushered in by several important

* H. M. Cadell, *op. cit.*, p. 175.

† Vol. xviii., pp. 231-3.

‡ "Geology of Edinburgh," *Mem. Geol. Survey*, 1910, p. 77.

§ "Geology of East Lothian," *Mem. Geol. Survey* (1910), p. 85.

|| D. Mushet, "Papers on Iron and Steel" (1840), pp. 119, 214 and 215.

¶ "Statistical Account of Scotland" (1792), vol. xiv., p. 627.

** D. Mushet, *op. cit.*, p. 216.

advances in blast-furnace practice. Two of these call for mention here :—

(i) The substitution of raw coal for coke. It was found that several of the Scottish seams, notably the Splint Coal of Lanarkshire, furnished a fuel which could be used without any preliminary coking.

(ii) The discovery of the advantages of introducing heated air, under pressure, into the furnace, in place of the cold blast hitherto employed. It was the success of Neilson's experiments, conducted between 1824 and 1828, that led to the use on a large scale of the refractory blackband ironstones or "hard binds," and to the rise of the great ironworks of the Coatbridge district.

The first blackband discovered was the Palacecraig Ironstone, found in 1801 by Mushet * when crossing the River Calder a little above Cairnhill Old Mill. Further search led to the discovery of the much more valuable ironstone known as the Airdrie or Mushet's Blackband, as well as of the Calderbraes or Kennelburn seam. Although Mushet clearly recognised their importance as potential ores, it was not found possible to employ them on any large scale until Neilson had demonstrated the superiority of the hot blast in their reduction. Tentative ventures had been made to smelt them first at Calder and later at Clyde by mixing them with clayband ores, but their use on an important scale dates only from about 1828. They were first used alone, according to Mushet,† at the Monkland Ironworks about 1825, and the success of this and later experiments led to the establishment of important works at Gartsherrie, Dundyvan, and elsewhere. The Airdrie Blackband soon became the most productive ironstone in Scotland, and by 1840 the Coatbridge district was the great seat of the iron industry. In this year the following furnaces were in blast there :—‡

Monkland	.	.	.	.	.	3
Calderbank	.	.	.	.	.	2
Calder	.	.	.	.	.	6
Dundyvan	.	.	.	.	.	5
Carnbroe	.	.	.	.	.	2
Gartsherrie	.	.	.	.	.	8 (7)
Summerlee	.	.	.	.	.	4 (5)

There were thus thirty furnaces in all, and the average output was some 90 tons a week each, derived wholly from blackband ores. If to these we add Clyde (four furnaces) and Govan (two), where blackband was mixed with half its weight of clayband, we find an average of thirty-three furnaces in Lanarkshire using blackband ores and manufacturing therefrom 3000 tons of pig iron a week.§

Even before 1828, and in addition to the Airdrie occurrences, blackbands were known at Crofthead (Fauldhouse), at Wilsontown, at Cadder, and elsewhere, and about 1835–1838 were found at Duntellan, Glasgow (Jordanhill), Dryden (Midlothian), and in Ayrshire. The Coltness works were erected in 1837 to smelt the well-known Slaty-

* See D. Mushet, "Papers on Iron and Steel" (1840), p. 121.

† *Ibid.*, p. 127.

‡ *Ibid.*, p. 128. See also "Statistical Account of Scotland" (1845), vol. vi., p. 659. The numbers in brackets in the list of furnaces on p. 8 are derived from the latter source.

§ D. Mushet, *op. cit.*, p. 129.

band of Crofthead and Fauldhouse. In Ayrshire furnaces were built at Blair, Glengarnock, Eglinton (Kilwinning), Dalmellington, Ardeer (Stevenson), Lugar (Cumnock), and Portland (Kilmarnock), between 1840 and 1850. Kilsyth and Denny, Fifeshire and the Lothians were all soon contributing to the new industry. In 1840 the blackband above the 2-ft. Coal of Clackmannan was discovered and worked for the Devon Ironworks. Towards the middle of the century workings in blackband seams in the Oakley and Cowdenbeath districts of Fife began, and the Forth, Lochgelly, and Lumphanans ironworks were set up. The Bo'ness blackbands for many years provided ore for the Kinneil and Bridgeness furnaces, and the small field of blackband in the Quarter district of Hamilton was worked for the old Quarter Ironworks from 1865–1869.

1860 ONWARDS. PERIOD OF IMPORTED ORES.

This period has witnessed a complete revolution in the conditions of the iron industry alike as regards raw materials, methods of manufacture and products. Even a brief analysis of the factors initiating and controlling this change is beyond the scope of these introductory notes, but the following remarks will serve to illustrate the nature of its effect in Scotland.

(1) The importation of foreign ores began in the early sixties, first exceeded half a million tons in 1887, and by 1906 had risen to slightly over two million tons: between 1906 and 1913 it twice almost touched the two million ton level.

(2) There has been a concurrent steady decline in the output of Scottish ores from approximately two and a half million tons in 1876 to considerably less than half a million in 1916 (see Figure 1).

(3) Fifty years ago that portion of the total output of the Scottish blast furnaces which was consumed in Scotland was devoted wholly to foundry and forge purposes.*

In 1913, on the other hand, the quantities and varieties of pig iron made were as follows:—

	Tons.	Percentage of Total Output.
Hæmatite	740,557	54·08
Foundry	424,200	30·98
Forge	127,566	9·31
Basic	69,269	5·06
Other Makes	7,667	0·56

The introduction of the Bessemer process of steel manufacture, first announced in 1856, marks the initial stage in this reversal of conditions. It was followed by the Siemens open-hearth process, projected in 1863, and established as a practical success about 1870. With extraordinary rapidity the new steel replaced wrought iron as a material of construction in such vital industries, for example, as railway engineering and (from 1880) shipbuilding. The discovery of the basic process in 1878–1879 enormously extended the limits of the steel industry, but it was the acid method of manufacture that attained a rapid and remarkable development in Scotland. The

* The remainder was either exported or added to stock. See "Mineral Statistics," *Mem. Geol. Surv.*, 1868, p. 86.

demand for non-phosphoric ironstone (*i.e.* ironstone with less than .03 per cent. of phosphorus), which alone was available for the acid process stimulated the growing export trade in high-grade ore from the Spanish and (to a less extent) Algerian mines. An additional factor was the increasing cost of mining the Scottish Carboniferous low-grade ores and the gradual exhaustion of the richer and more accessible fields. The total ore used in Scotland in 1913 was nearly three million tons, of which only 591,561 tons were derived from Scottish sources. The great import trade in Spanish haematite which arose in reply to the demand for a non-phosphoric ore has, in spite of the basic process, inevitably retained its ascendancy. Phosphoric ores have come, however, to play an increasingly important part in the world's steel industry (see, for example, "Iron and Coal Trades Review," Nov. 18, 1910), and it seems probable that the basic open-hearth process will ultimately be the one generally adopted.

Great advances in blast furnace practice have also marked this period. These have involved the demolition of many furnaces and their replacement by others of more modern design, the addition of by-product recovery plants, etc. The actual number of furnaces has decreased, but the average weekly output has gone up from 165 tons in 1872 to about 300 tons in 1916.

TABLE I.—*Production of Pig Iron during the Period 1760–1853.*

Year.	Pig Iron Output.	Furnaces in Blast.	Percentage of Total Output of the United Kingdom.	Authority.
1760	Tons. 6 or 700	1	...	i.e. Lorne Furnace. Meade, "Coal and Iron Industries," 1882, p. 727.
1788	{ 1,400 5,600	2 6	10·25	Lorne and Goatfield. Mushet, "Papers on Iron and Steel," 1840, p. 44.
				Carron and Wilsontown. Meade, <i>op. cit.</i> , p. 729.
1795	16,086	17	12·8	Mushet, <i>op. cit.</i> , p. 413, quoting returns to House of Commons Committee.
1796	18,640	...	(14·9)	R. Moore in St. John V. Dav's "Leading Industries of Glasgow," 1876, p. 14.
1806	22,840	17	9·3	Meade, <i>op. cit.</i> , p. 731. Moore, <i>loc. cit.</i> , gives 20,240.
1823	24,500	22	5·4	Meade, <i>op. cit.</i> , p. 732 ("not more than 24,500").
1830	37,500	24	5·5	Meade, <i>op. cit.</i> , p. 734
1835	75,000	29	10·7	"Statistical Account of Scotland," vol. vi., 1845, p. 161.
1839	196,000	54	(14·5)	Mushet, <i>op. cit.</i> , p. 413.
1840	197,000	...	(15·7)	Moore, <i>loc. cit.</i>
1843	311,000	62	25·6	Meade, <i>op. cit.</i> , p. 736.
1845	475,000	88	(31·4)	"Mineral Statistics," <i>Mem. Geol. Survey</i> , 1858, p. 99.
1846	570,000	98	...	<i>ibid.</i>
1847	510,000	100	(25·5)	<i>ibid.</i>
{ 1848	580,000	103		<i>ibid.</i>
{ 1848	534,000	89	26·7	Meade, <i>op. cit.</i> , p. 737.
1849	690,000	112	...	"Mineral Statistics," 1858, p. 99.
1850	595,000	105	(25·8)	<i>ibid.</i>
1851	760,000	112	...	<i>ibid.</i>
1852	775,000	113	(28·6)	<i>ibid.</i>
1853	710,000	114	.	<i>ibid.</i>

Notes on above Table.

- (1) The percentage figures in brackets are calculated on total make of pig iron in Great Britain as given in Hood, "Iron and Steel," Appendix.
- (2) The sudden rise in pig iron production after 1830 marks the introduction of blackband ores.
- (3) The increased production shown by the figures for 1840 and 1845 is due to the impetus given to the iron industry by the great extension of the railway system.

TABLE II.—*Production of Iron Ore and of Pig Iron for the Period 1854–74.*

Year.	Iron Ore Output.	Percentage of Total Output of the United Kingdom.	Pig Iron Output.	Number of Furnaces in Blast.	Percentage of Total Output of the United Kingdom.	Character of Ore.		
1854	Not given	...	796,640	118	25·95			
1855	2,400,000	25·1	827,500	122	25·71	Clayband and Blackband.		
1856	2,201,250	21·0	880,500	127	24·44			
1857	2,500,000	26·1	918,000	124	25·08	Clayband, Blackband, and Hæmatite.		
1858	2,312,000	28·7	925,500	132	26·78	" "	" "	" "
1859	2,225,000	28·2	960,550	125	25·87	" "	" "	" "
1860	2,150,000	26·8	937,000	131	24·48	" "	" "	" "
1861	1,975,000	27·4	950,000	124	25·58	" "	" "	" "
1862	1,500,000	19·8	1,080,000	125	27·31	" "	" "	" "
1863	1,500,000	16·5	1,160,000	134	25·72	" "	" "	" "
1864	1,950,000	19·4	1,158,750	131	24·30	" "	" "	" "
1865	1,470,000	14·8	1,163,478	141	24·14	Clayband and Blackband.		
1866	1,587,000	16·4	994,000	98	21·97			
1867	1,264,800	12·6	1,031,000	112	21·65	" "	" "	
1868	1,250,000	12·3	1,068,000	123	21·48	" "	" "	
1869	1,950,000	17·0	1,150,000	132	21·11	" "	" "	
1870	1,980,000	13·8	1,206,000	123	20·22	" "	" "	
1871	1,975,000	12·1	1,160,000	127	17·50	" "	" "	
1872	1,978,000	12·7	1,090,000	130	16·16	" "	" "	
1873	1,986,000	12·7	993,000	126	15·12			
1874	2,119,771	14·3	807,677	128	13·48	Clayband, Blackband, and Hæmatite.		

Notes on above Table.

- (1) The figures for output of iron ore are taken from "Mineral Statistics," 1854–74, *Mem. Geol. Survey*, with the exception of those for the three years 1870–2, which are quoted from Meade, "Coal and Iron Industries of the United Kingdom," 1882, p. 724. The "Mineral Statistics" for these years give 3,000,000, 3,300,000, and 3,270,000 tons respectively, but Meade, who was Assistant Keeper of Mining Records, does not adopt these figures himself. The sudden increase in 1870 is explained in the introduction to "Mineral Statistics" for that year as due to the fact that "in former years a considerable quantity of calcined ore was reckoned as such, whereas it has all now been computed into raw ore." The impossibility of determining whether the returns voluntarily made to the Mining Records Office are for calcined or raw ores is referred to several times (see "Mineral Statistics," 1864, pp. 52 and 61; 1865, *Introd.*, p. vi.; 1871, *Introd.*, p. vi., etc.). For the years previous to 1872, therefore, two points must be borne in mind—(1) the returns are voluntary, and (2) they may include a good deal of calcined ore.
- (2) The hæmatite mentioned as contributing to the output for 1857–64 must be quite inconsiderable. In 1874 Shetland produced 692 tons of bog ore, and the Garleton Mines (Haddington) 10,283 tons of hæmatite. In all other years only clayband and blackband seams of Carboniferous age were being wrought.
- (3) The figures for output of pig iron and for number of furnaces in blast are taken from "Mineral Statistics" (*Mem. Geol. Survey*).
- (4) Meade in "Coal and Iron Industries," gives figures for the make of pig iron which differ slightly in some cases from those quoted. His statistical tables go up to 1880.

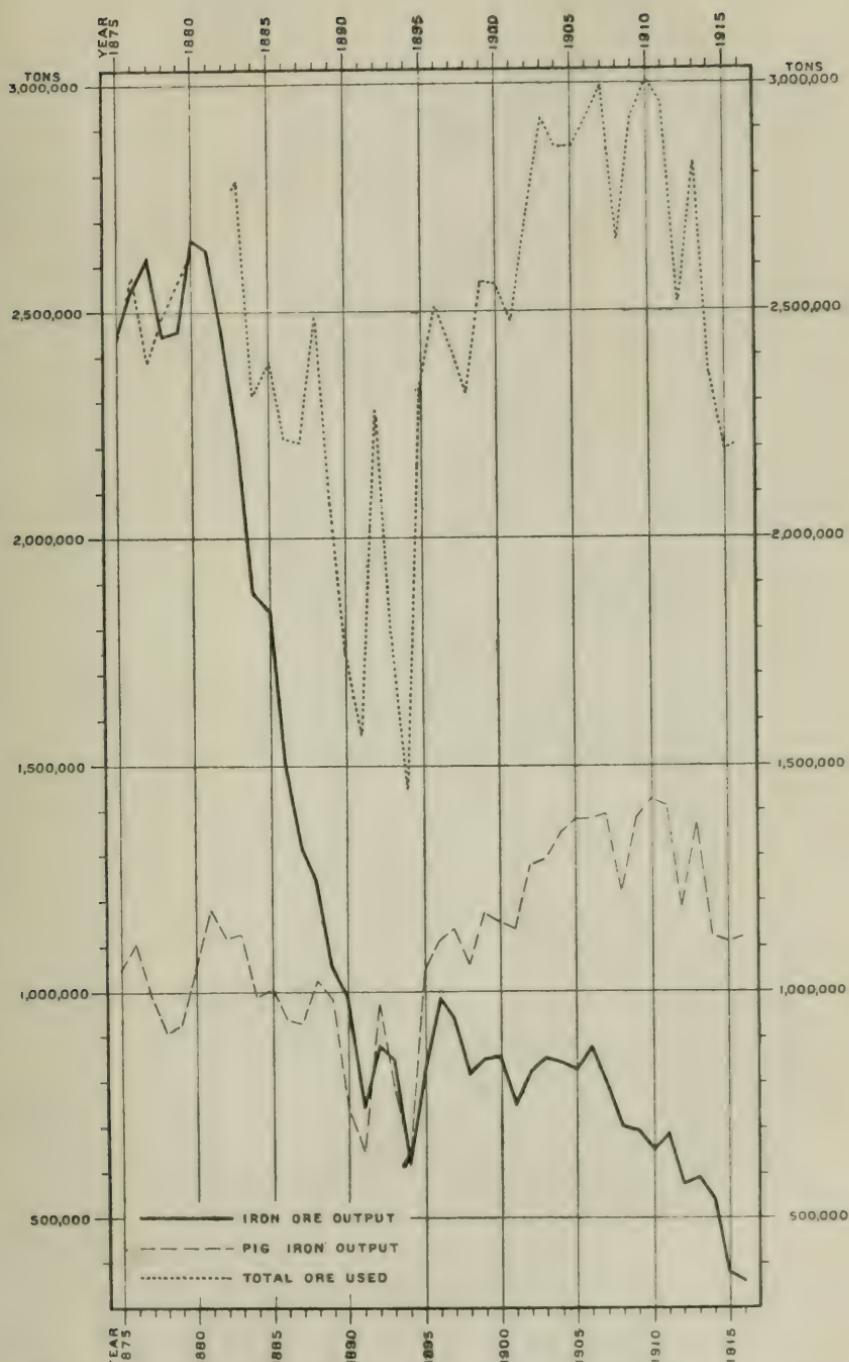


FIG. 1.—Diagram to show Iron Ore produced, amount of Ore used, and Pig Iron made in Scotland during the years 1875-1916.

*The Iron Ores of Scotland*TABLE III.—*Iron Ore produced, Pig Iron made, and Total Ore used in Scotland between 1875–1917 (see Fig. 1).*

Year.	Iron Ore Output.	Percentage of Total Output of the United Kingdom.	Pig Iron Output.	Total Ore Used.	Number of Furnaces in Blast	Percentage of Total Output of Pig Iron of the United Kingdom.
	Tons.		Tons.	Tons.		
1875	2,452,235	15·5	1,050,000	(2,400,000)	119	16·49
1876	2,551,551	15·15	1,103,000	(2,575,000)	119	16·82
1877	2,621,852	15·7	982,000	(2,385,000)	109	14·86
1878	2,443,923	15·5	902,000	(2,490,000)	94 $\frac{1}{2}$	14·13
1879	2,458,407	17·1	932,000	(2,560,000)	96 $\frac{1}{2}$	15·54
1880	2,664,483	14·8	1,049,000	(2,628,610)	112 $\frac{1}{2}$	13·53
1881	2,600,510	14·9	1,176,000	...	114 $\frac{3}{4}$	14·43
1882	2,406,084	13·3	1,126,000	...	110	13·11
1883	2,228,851	12·8	1,129,000	2,788,000	107 $\frac{1}{2}$	13·23
1884	1,885,376	7·3	988,000	2,310,899	98	12·64
1885	1,838,423	11·9	1,003,562	2,380,000	92	13·53
1886	1,507,534	10·7	935,801	2,225,000	86 $\frac{1}{4}$	13·35
1887	1,321,899	10·1	932,240	2,218,500	84	12·33
1888	1,238,597	8·5	1,027,774	2,472,716	85 $\frac{1}{4}$	12·84
1889	1,061,734	7·3	978,203	2,069,513	84 $\frac{1}{2}$	11·73
1890	998,835	7·2	737,066	1,733,269	65 $\frac{1}{2}$	9·32
1891	748,336	5·9	674,076	1,568,473	63 $\frac{6}{12}$	9·10
1892	872,435	7·7	972,493	2,272,336	77 $\frac{3}{12}$	14·49
1893	847,406	7·6	793,055	1,780,134	64 $\frac{8}{12}$	11·36
1894	631,304	5·1	642,243	1,440,521	52 $\frac{1}{2}$	8·64
1895	824,673	6·5	1,048,774	2,331,664	76 $\frac{1}{2}$	13·61
1896	983,670	7·2	1,114,038	2,509,136	80 $\frac{1}{2}$	12·86
1897	936,850	6·8	1,136,507	2,419,671	79 $\frac{1}{2}$	12·92
1898	824,219	5·8	1,062,547	2,318,166	78	12·34
1899	843,585	5·8	1,170,830	2,564,672	85 $\frac{1}{2}$	12·42
1900	849,031	6·	1,156,885	2,562,926	85 $\frac{5}{12}$	12·91
1901	759,373	6·2	1,136,396	2,470,184	82 $\frac{1}{2}$	14·33
1902	828,314	6·2	1,271,716	2,700,626	86 $\frac{1}{2}$	14·65
1903	846,094	6·2	1,290,790	2,921,781	87 $\frac{1}{2}$	14·44
1904	838,104	6·1	1,351,147	2,862,997	86 $\frac{3}{12}$	15·54
1905	832,388	5·7	1,375,125	2,864,289	87 $\frac{9}{12}$	14·31
1906	875,358	5·6	1,376,888	2,919,396	91 $\frac{6}{12}$	13·52
1907	799,148	5·1	1,389,474	2,998,098	91 $\frac{1}{2}$	13·73
1908	704,053	4·7	1,224,802	2,645,767	76 $\frac{1}{2}$	13·52
1909	697,276	4·7	1,377,247	2,918,324	83 $\frac{9}{12}$	14·44
1910	648,415	4·3	1,427,828	3,011,306	87 $\frac{2}{12}$	14·26
1911	689,133	4·4	1,408,555	2,959,864	85 $\frac{6}{12}$	14·78
1912	569,971	4·1	1,185,520	2,513,979	77 $\frac{1}{2}$	13·54
1913	591,561	3·7	1,369,259	2,818,923	87 $\frac{1}{2}$	13·34
1914	538,066	3·6	1,125,967	2,357,335	72 $\frac{3}{12}$	12·61
1915	375,241	2·63	1,109,177	2,193,257	71 $\frac{6}{12}$	12·71
1916	365,748	2·71	1,124,862	2,212,438	76 $\frac{1}{2}$	12·61
1917	444,327	2·99	1,156,924	2,252,617	80 $\frac{1}{2}$	12·38

Notes on above Table.

(1) Iron Ore Output.—The figures given under this heading are taken from "Mineral Statistics" (Geological Survey and Home Office), and are based on the returns made to H.M. Inspectors of Mines under the powers conferred by the Coal Mines Regulation Act, and by the Metalliferous Mines Regulation Act, both of 1872. In 1897 "Mineral Statistics" was replaced by Part III. of "Mines and Quarries" (Home Office). All the iron ore, with the following exceptions, falls into the category of Carboniferous clayband and blackband.

Year	Ore.	Tons.	Locality.
1875 . . .	Hæmatite.	6568	Sandlodge and Garleton.
1876 . . .	"	4224	Auchinlongford and Sandlodge.
1877 . . .	"	5469	Auchinlongford.
1878 . . .	"	7568	Sandlodge
1879 . . .	"	492	Auchinlongford and Sandlodge
1880 . . .	"	5166	(396 tons).
1881 . . .	"	5135	Auchinlongford.
1882 . . .	"	1907	
1884 . . .	"	2218	
1885 . . .	"	3264	Noblehouse.
1886 . . .	"	803	
1911 . . .	Chamosite.	4644	
1914 . . .	"	6791	
1915 . . .	"	Not given.	Raasay.
1916 . . .	"	"	
1917 . . .	"	"	

For the years 1878-80 separate returns are made for clayband and blackband as follows :—

Year.	Clayband.	Blackband.
1878 . . .	1,123,772	1,312,583
1879 . . .	1,135,247	1,322,668
1880 . . .	1,223,670	1,435,647

(2) Pig Iron Output and number of Furnaces in blast are taken from "Mineral Statistics" and (since 1897) from "Mines and Quarries," Pt. III.
 (3) Total Ore Used.—The figures for 1878-80 are those given by Meade in "Coal and Iron Industries" (1882, p. 752). From 1883 onwards they are to be found in "Mineral Statistics," or in its equivalent in "Mines and Quarries."

SUMMARY OF ESTIMATED RESERVES.

Type of Ore and District.	For Detailed Tables see	Reserves in Tons.	
		Probable.	Possible.
(1) Bedded Carboniferous Ores.			
Ayrshire	p. 48	62,150,000	69,140,000
Central Coalfield	p. 134	18,603,200	342,570,000
Fifeshire	p. 163	1,369,000	6,874,400
Midlothian	p. 195	2,302,400	4,646,000
(2) Bedded Jurassic Ores.			
Raasay	p. 200	10,052,160	11,886,000
Totals		94,476,760	435,116,400

This table, which summarises the more detailed ones to be given later, is merely an attempt to express in round figures the reserves of ore available in the more important ironstone districts in Scotland. It may be advisable to indicate here the methods by which these tables have been compiled. For the most part the seams taken into consideration are either worked at present, or have been wrought

within comparatively recent times. In some cases the figures given have been corroborated by the mineral lessees concerned, and may be regarded as substantially accurate; in others the evidence is much less satisfactory. The criteria used in separating "probable" from "possible" reserves are, of course, not absolute. They rest ultimately on the number of records of thickness available, but the inferential value of these depends in turn upon the nature of the seam and upon our knowledge of its behaviour in areas where it has been worked. Estimates of blackband ores, which are notoriously variable and impersistent, require to be supported by many more boring records than are generally available, and for lack of these some seams of this nature have had to be wholly or in part neglected. In dealing with claybands we are on somewhat firmer ground, but here again no attempt has been made to furnish figures for the thin lenticular ribs or nodular layers overlying worked or workable coals. The term "possible" as used in the tables refers to reserves in areas where the ironstone, to judge by its persistence in adjoining districts, is certainly present, but where there is little or no direct evidence regarding its thickness or quality. In the case of "probable reserves," on the other hand, the evidence, both direct and indirect, is much stronger, so that, in most cases at least, the areas concerned may be regarded as semi-proved. It ought also to be added that the important factor of depth has to be considered. If we extended the more persistent seams into areas where they must lie at depths at present considered impracticable (say, over 300 fms), the total "possible" reserves would be enormously increased.

The yield of ore per acre has in general been arrived at by multiplying the number of tons in an inch-acre of water (101) by the specific gravity of the seam, and by its thickness in inches. No allowances have been made for losses in working (due to such causes as "wants," "thin stone," faulted ground, permanent pillars, etc.), and to cover these a deduction of approximately 30 per cent. should be made. This would reduce the total amount of "probable reserve" to about sixty-six millions of tons.

CHAPTER II.

BEDDED ORES OF CARBONIFEROUS AGE.

Ayrshire ; Lanarkshire (Bankend, Douglas and Coalburn).

INTRODUCTION.

THE ironstones of Carboniferous age in Ayrshire include both claybands and blackbands, and just as in the Central Coalfield, in Fife-shire and in the Lothians, are found chiefly in the Limestone Coal Group. Of the other subdivisions of the Carboniferous Formation, the Productive Coal Measures alone contains ironstones of economic value, although one or two thin claybands are locally found in association with the Lower Limestone Group, *e.g.* in the Muirkirk district. No ironstone horizon of any importance is known in the Upper Limestone Group, while the Calciferous Sandstone Series, apart from a few thin beds of bole noticed in connection with the mugearitic lavas in the hills to the north-west of Dalry, is equally barren. The lateritic ironstones associated with the Millstone Grit volcanic rocks stand in a class by themselves, and are dealt with later in a separate section.

LIMESTONE COAL GROUP.

Although this group of rocks has a wide extension in Ayrshire it is only in certain areas that the associated seams of ironstone are thick enough and of suitable quality to work. The New Cumnock and Dailly coalfields, for example, contain no ironstones of workable thickness. In other districts again, such as Ayr and Troon, nothing whatever is known of the character of the Limestone Coal Group. This well-marked division into productive and non-productive areas necessitates the adoption of certain geographical units as a basis for the detailed account which follows. The following districts, arranged more or less in geographical order from north to south, have accordingly been selected for separate description :—

- Lugton and Caldwell.
- Kilbirnie and Lochwinnoch (see Fig. 2).
- Glengarnock and Dalry (see Fig. 3).
- Kilmarnock.
- Cumnock, Lugar, and Muirkirk (see Fig. 6).

The first three areas are by far the most important and together comprise all the ground occupied by Limestone Coal Group strata in the north-west quarter of 1-in. Geological Survey Sheet 22. Of the ironstones that have been worked here the most important are

the Dalry Clayband and the Dalry Blackband. Other fairly persistent horizons are the Garibaldi Claybands and Logan's Claybands.

A few notes may be given here regarding the equivalents of these horizons in the Central Coalfield. The Dalry Clayband, occurring at the top of the blaes above the highest of the Lower Limestones, is represented in the Paisley-Glasgow district by the Johnstone Clayband, which occupies a similar position in the local sequence. Both in North Ayrshire and in the Central Coalfield an excellent index-mark for this ironstone is furnished by the widely-developed marine horizon known as the Johnstone Shell-bed which is found not far above it. The Garibaldi Claybands correspond to the ironstones of the same name formerly worked at Ibrox, Garscube, Gartnavel, etc. (see p. 75). The Dalry Blackband appears to occupy approximately the same geological position as the Lower Garscadden Blackband of the Glasgow district or the Banton Blackband of Kilsyth. Logan's Claybands again are represented in the Central Coalfield by the ironstones of the Black Metals, *i.e.* the California Claybands, Banton Claybands, etc.

Lugton and Caldwell.

Six-inch Ordnance and Geological Survey Sheets:—Ayr, 8 N.E., S.E.; 9 N.W., S.W.; Renfrew, 15 S.E.

Strata of Limestone Coal Group age occupy here a small basin about one square mile in extent. Along the northern margin of the area they are faulted against Calciferous Sandstone volcanic rocks, but outcrop to the east, south, and west. The general section of the metals near Caldwell is as follows:—

	Fms.	Ft.	In.
BORESTONE COAL	1	0	0
Strata, mainly sandstone	2	0	0
COAL, parrotty	0	0	11
Strata, mainly sandstone	6	0	0
Blaes, with ironstone balls	1	4	0
COAL, foul	0	0	5
Strata, mainly sandstone	6	0	0
Blaes, with thin clayband ribs	3	0	0
Sandstone and fakes	5	0	0
LOGAN'S BANDS, blaes, with clayband ribs	2	2	0
Strata, mainly sandstone	7	0	0
Blaes	2	0	0
CLAYBAND (? DALRY BLACKBAND position)	0	0	10
Blaes	2	0	0
CLAYBAND RIBS (? GARIBALDI)	0	0	3
Strata, mainly sandstone	9	0	0
Blaes, with thin clayband ribs	8	0	0
Sandstone	5	0	0
Blaes	2	0	0
DALRY CLAYBAND	0	1	5
Blaes	3	0	0
(TOP HOSIE LIMESTONE)	(1	0	0)

Dalry Clayband.—This seam, the most important in the area, has been worked to a small extent in shallow pits between Lugton and Caldwell Stations, where it averages 14 or 15 inches. As the ironstone is of fairly uniform thickness over the whole area it occupies,

there is approximately one square mile of the stone still available to work.

Garibaldi Claybands and Dalry Blackband.—Several thin clay-band ribs, varying from 2 to 10 in., are found in the Caldwell district in the position of the seams mentioned. They lie about 26 fms. above the Dalry Clayband, but very little can be inferred as to their quality or extent. Near Caldwell they occur at a depth of, roughly, 40 fms.

Logan's Bands.—A bore near Caldwell recorded the following section of these ironstones at a depth of 30 fms:—

		Ft. In.
Blaes . . . . .	. . . . .	4 7
IRONSTONE . . . . .	. . . . .	0 3
Blaes . . . . .	. . . . .	2 5
IRONSTONE . . . . .	. . . . .	0 3
Blaes . . . . .	. . . . .	0 8
IRONSTONE . . . . .	. . . . .	0 3½
Blaes . . . . .	. . . . .	2 7

This section shows 9½ in. of clayband in a possible working of nearly 4 ft. Nothing is known of the quality of the ironstones, and it is very doubtful if they have any economic value.*

ESTIMATED RESERVES—CALDWELL-LUGTON AREA.

Name of Seam.	Average Thickness.	Area in Acres.	Reserves in Tons.	
			Probable.	Possible.
Logan's Bands	9 in.	300 ?	...	870,800 ?
Garibaldi Claybands	6 in.	500 ?	...	900,000 ?
Dalry Clayband	14–15 in.	640	3,500,000	...

Kilbirnie and Lochwinnoch.

Six-inch Ordnance and Geological Survey Sheets:—Ayr, 4 S.E.; 5 S.W.; 7 N.E.; 8 N.W.; Renfrew, 14 N.E., S.E.; 15 N.W., S.W.

The Limestone Coal Group of this district (see Fig. 2) occupies an area of about 4½ square miles in the form of a small basin elongated in a north-easterly direction. The basin is defined on the west and north mainly by outcrop, to the east partly by outcrop, partly by a series of north-east faults with downthrows to the north-west.

The general sequence of the Limestone Coal Group here is graphically shown in Fig. 4.

Dalry Clayband.†—The outcrop and distribution of this seam, and the positions of known workings in it, within the Kilbirnie-Lochwinnoch area, are shown in Fig. 2. It has only been wrought

* Cf. note on same beds in the Paisley and Johnstone district on p. 81.

† The notes on the Dalry Clayband, Pundeavon Ironstone, Maich Musselband, and Logan's Bands of this area have been contributed by Mr. C. H. Dinharn.

to a very limited extent in this area, and natural exposures are not abundant; on the other hand, there is every reason to suppose that the clayband is constant, since it does not appear to have been missed in any bore passing through the position. Near its most northerly outcrop on Risk Farm, Castle Semple, the ironstone was recorded 12 in. thick, and it has also been found near Lochside Station, about 44 fms. below the surface. A 20-in. clayband found at 40 fms. in a bore on Hole, near Barr Castle (Renfrew, 15 N.W.), may perhaps have been the Dalry seam. In the Lora Burn, 350 yds. S.E. of Glenlora Bridge, there is a partial exposure of this horizon; the seam is here in two plies, the top one, at least 9 in. thick, containing 35·4 and 38·3 per cent. of iron in two calcined samples, while the lower ply, 3½ to 5 in. thick, and separated

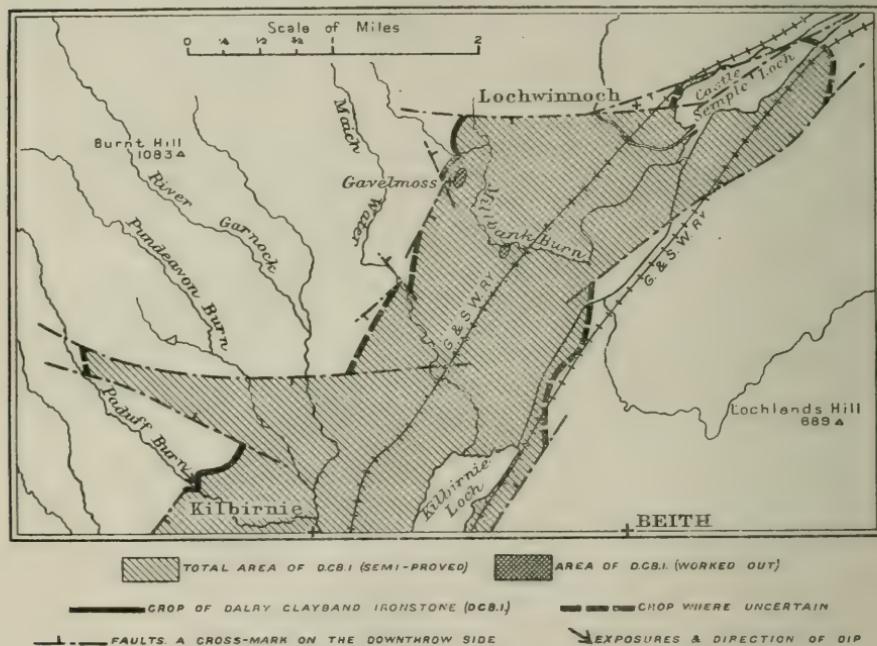


FIG. 2.—Geological Sketch-Map of the Kilbirnie-Lochwinnoch Ironstone Field.

from the other by 4 in. of soft blaes, contains 34·8 per cent. of iron after calcination. Close by on Gavelmoss the Dalry Clayband is said to have been wrought, but evidently only on a small scale; the thickness here and in neighbouring bores was 14 to 21 in. The old pit on the south bank of the Millbank Burn, N.N.E. of Jeffreystock (Renfrew, 14 N.E.), as well as a neighbouring bore, are reported to have reached a 28-in. clayband at depths (44 and 40 fms.) which suggest the Dalry seam, but the thickness recorded is exceptional. The horizon is faulted out of the Maich Water section, but should occur at a depth of about 10 fms. in the corner of the L-shaped bend about 300 yds. S.W. of Langstilly, just opposite the limy "ironstone-kingles" (see following paragraph) which are there seen. In the Pundeavon Burn the Dalry Clayband is again faulted out of the natural section, but ought to occur some 12 fms. under

the Pundeavon Ironstone there exposed. In the western part of this area, south of Lochside Station, nothing is known of the development of the seam; it may be expected, however, to lie only a few fathoms below the surface in the immediate vicinity of Beith (Main Line) Station (Ayr, 8 N.W.).

Throughout the Kilbirnie-Lochwinnoch area the Dalry Clayband lies in the middle of a bed of blaes, several fathoms thick, in which *Lingula* is rare and marine fossils are absent. No sandstone intervenes between the ironstone and the top limestone of the Lower Limestone Group.

Pundeavon Ironstone.—Like the Dalry Clayband this seam occurs in the middle of a thick bed of blaes, but lies some 11 fms. higher in the sequence. The blaes at this horizon, moreover, contain *Lingula* in extreme abundance, and marine lamellibranchs are not uncommon. This feature serves to prevent confusion with the Dalry Clayband in boring operations. The lower part of these fossiliferous blaes, 2 or more fms. below the Pundeavon Ironstone, is still more markedly marine and represents the Johnstone Shell-bed (see p. 21). Just underneath the Shell-bed are found one or two limy ironstones or iron pyrites, which are seen in natural section in the Maich Water at the bend S.W. of High Langstilly, mentioned in the preceding paragraph.* It may be noted here that apart from these "pyrites," the strata between the Dalry Clayband and the Johnstone Shell-bed consist, in the vicinity of Kilbirnie, entirely of blaes with occasional ironstone ribs of no value; in the Maich Water, however, sandstones begin to intervene below the Shell-bed, and these grow progressively thicker to the north, as can be proved both near Castle Semple Loch and in the nearest parts of the Central Coalfield area.

The Pundeavon Ironstone is poorly exposed in the Paduff Burn; it is much better seen in the Pundeavon Burn, 100 yds. south of the Kilbirnie Filter Beds, and again downstream west of Bankside. The seam here is 9 in. thick with a 2-in. limy ply in the middle showing cone-in-cone structure. The top and bottom plies yield on calcination 37·5 per cent. of iron. In the Maich Water the ironstone is conspicuously exposed north-west of Nervelston, where the section of the seam is as follows:—

Top ply,	2 in.	Iron on calcination	36·1	per cent.
Middle ply, 6 to 7 in.	" "	14·9	"	"
Bottom ply, 3 in.	" "	28·6	"	"

The seam is fairly constant in bores near Kilbirnie, varying in thickness from 5½ to 9 in. In the Millbank Burn, 200 yds. E.S.E. of Plently, the ironstone was formerly found 9 in. thick. In a bore south of Lochwinnoch it appears as 16 in., in two plies separated by one foot of blaes.

The Pundeavon Ironstone is generally more or less limy, especially in the central ply. Being comparatively poor in quality, and only of moderate thickness, it has very little economic value. It is described here in some detail, chiefly in order to avoid possible confusion with the underlying Dalry Clayband.

Maich Musselband Ironstone.—This horizon occurs in the Kilbirnie-

* See also p. 24.

Lochwinnoch area, about 5 to 7 fms. below the Dalry Blackband. The most northerly exposure is in the railway cutting (Renfrew, 11 S.W.) nearly a mile north of Lochside Station, and west by south of Risk. The section seen is as follows:—

	Ft.	In.
Blaes with thin CLAYBAND ribs	about 6	0
Cone-in-cone CLAYBAND, very limy	0	1½
Layer of crushed "mussels" (<i>Naiadites</i>)	0	1
Cone-in-cone CLAYBAND, limy	0	1½
CLAYBAND with <i>Naiadites</i>	0	4
Cone-in-cone CLAYBAND	0	2
Hard blaes with <i>Naiadites</i> , 2 to 3 in	0	2
Blue blaes with a 2 to 2½-in. clayband	1	9
PARROT COAL or parrotty blaes, <i>Lingula</i> at top	0	3
Blue blaes	1	0
Ferruginous kingly sandstone	0	10

The seam rapidly varies in character, and in other parts of the same exposure the top 3 in. of the preceding section appears to be replaced by a poor blackband. Hitherto the Maich Musselband has been correlated with the Dalry Blackband, but it is probable that the latter is really represented by a 10-in. coal lying 6 or 7 fms. above the Musselband. Fragments of the Musselband are found in the old waste heaps between the railway and the loch, and it is possibly this ironstone, and not the Dalry Blackband, which was worked in the old mine and pits of the neighbourhood. What appears to be the same horizon is recorded as a "coarse ironstone 10 in." at a depth of 4 fms. below the Dalry Blackband position in an old bore west of Calderhaugh Mill, Lochwinnoch.

The Maich Musselband is exposed in the Maich Water at the foot of the cliff on the left bank, 200 yds. S.S.W. of Nervelston (Renfrew, 14 N.E.), where it shows:—

	Ft.	In.
DALRY BLACKBAND (Blackband 4 in. on coal 8 in.)	1	0
Fireclays and blaes with thin claybands and a 4-in. coal at base	10	0
Faky sandstone (very constant horizon)	5	6
Blaes with thin clayband ribs	6	0
MAICH MUSSELBAND, blaes with thin clayband ribs and very abundant <i>Naiadites</i>	1	3
Blaes with clayband ribs	4	4
Hard limy or siliceous clayband	0	10

There is no doubt that this Musselband must lie very nearly on the same stratigraphical horizon as the Garibaldi Claybands, described later on p. 29. The latter seam is not known, however, to be connected with a musselband, and until more evidence on this point is available the exact correlation must remain an open question. It is possible it may be represented by the ferruginous "kingle" or limy ironstone at the foot of the preceding tabulated sections. If so, the Garibaldi Ironstone deteriorates in quality when followed northwards. On the assumption that the Maich Musselband is the Garibaldi it is evidently very variable in composition, though once considered workable near Castle Semple Loch. A third possibility, that the Garibaldi position lies between the Dalry Blackband and the Maich Musselband, is suggested by the fact that in Wheatyfaul Pit, within the Dalry-Glengarnock area, the supposed position of the

Garibaldi lies $2\frac{1}{2}$ fms. below the Blackband, and three fms. above a musselband corresponding in position exactly to the Maich Musselband.

Dalry Blackband.—This ironstone, where worked at Glengarnock, was inferior in quality and in thickness to the same seam farther south-west at Dalry; and when followed north-eastwards appears to deteriorate still farther. So far as is known it is represented in most cases in the Kilbirnie-Lochwinnoch area by a thin coal associated with iron ribs (see, for example, the section on p. 26).

Logan's Claybands.—These ironstones take their name from the proprietor of an old pit near Baillieston (Ayr, 7 N.E.), where they are said to have been formerly worked. This pit is believed to have been a failure, but from what cause is unknown. Where exposed in the Paduff Burn, just above the Largs road, the horizon is certainly of good thickness and quality, as the following details show:—

TOP CLAYBAND, 4 to $4\frac{1}{2}$ in.	Fe 44·16 per cent. (calcined)*
Blaes and fakes, 2 ft.	"
MIDDLE CLAYBAND, 5 $\frac{1}{2}$ to 6 in.	Fe 42·50 per cent. "
Blaes, $1\frac{1}{2}$ to 2 ft.	"
BOTTOM CLAYBAND (nodular), 3 to 9 in.	Fe 46·27 per cent. "

Some of the bands can also be seen in the railway cutting north of Kilbirnie (G. and S.W.) Station, near Bridge 50; the section being:—

	Ft. In.
Hard blaes with <i>Lingula</i>	1 0
CLAYBAND RIB, fair quality	0 2
Blaes	0 10
CLAYBAND RIB, poor quality	0 2
Blaes	3 0
CLAYBAND with 1-in. parrotty parting	0 8
Parrotty blaes, abundant fish-teeth	0 2
Fireclay blaes with clayband nodules	0 10
NODULAR CLAYBAND, 5 to 12 in.	0 9

Other exposures occur in the Millbank Burn, 1 mile south-east of Lochwinnoch: (1) between the railway embankment and the main road; (2) 200 yds. S.E. of Millbank Bridge. The thickest band here is 11 in., but is very calcareous.

ESTIMATED RESERVES IN KILBIRNIE-LOCHWINNOCH AREA:—

Name of Seam.	Average Thickness.	Area in Acres.	Reserves in Tons.	
			Probable.	Possible.
Logan's Bands.	12 in.	1920	...	6,000,000
Garibaldi Claybands?	6 in.	2000	...	3,600,000
Pu deavon Ironstone	11 in.	2400	...	7,920,000
Dalry Clayband	16 in.	2880	12,000,000	...

* Analyses by D. Colville & Sons, Motherwell.

Dalry and Glengarnock.

Six-inch Ordnance and Geological Sheets ; Ayr, 7 S.W., S.E. ; 8 S.W., S.E. ; 11 ; 12 ; 16 N.W., N.E. ; 17 N.W., N.E.

The northern boundary of this district (see Fig. 3) is defined by an east-and-west line drawn through Beith and the south end of Kilbirnie Loch. From this line an elongated area of Carboniferous Limestone rocks extends southwards to Girthill and Caddell. The more productive parts of the various ironstones are to be found in what is known as the Dalry basin, and in the southern portion of the Kilbirnie basin. The term basin is here used very loosely, although there is a distinct synclinal fold near Kilbirnie where the rocks dip towards an axis running along the length of Kilbirnie Loch. Near Dalry, however, the structure is somewhat different, and, while slight local flexures occur, the general dip of the strata is to the south-east. On the north-west margin of this district the Carboniferous Limestone rocks are usually faulted against Calciferous Sandstone lavas, though here and there the junction is a normal one. To the south-east again the boundary is defined by the Dusk Water fault. This dislocation runs north-eastwards from Ashgrove Loch, crosses the River Garnock about half a mile south-east of Monkcastle, and then follows the course of the Dusk Water to Hessilhead. On the south-east or upthrow side of this fault the ironstones are in general too thin to be of any economic value. Several other large faults cross the Dalry-Glengarnock field, and their positions are shown in Fig. 3.

In Fig. 4 will be found a table of comparative vertical sections of the Limestone Coal Group as developed at Glengarnock, Dalry, Caddell, and Monkredding.

Dalry Clayband.—This seam, the lowest workable ironstone of the district, lies 3 to 5 fms. above the Top Hosie Limestone, and about 6 fms. below the Johnstone Shell-bed. The seam itself may usually be distinguished by :—

(1) The absence of the marine fossils and *Lingula* which occur in association with the higher horizon known as the Pundeavon Clayband (see p. 21).

(2) The presence of entomostraca in the hard blaes immediately below the seam.

(3) The occurrence of two or three bands of blue "ironstone kingle" in the blaes overlying the clayband (see p. 21).

The Dalry Clayband is persistent throughout the district, and varies in thickness from 6 to 20 in. It may occur in one ply or in two or even three ribs separated by partings of blaes. The following table shows the total thickness of ironstone at this horizon in different localities :—

(1) North of the Dusk Water fault—

	In.
Dockra, bore	20
Birsieknowe, pit	16
Glengarnock, pit	15
Paduif Burn, natural section	$14\frac{1}{2}$
Gowhouse Burn, natural section	$14\frac{1}{2}$
Barkip No. 8 Pit	14
" No. 7 Pit	16

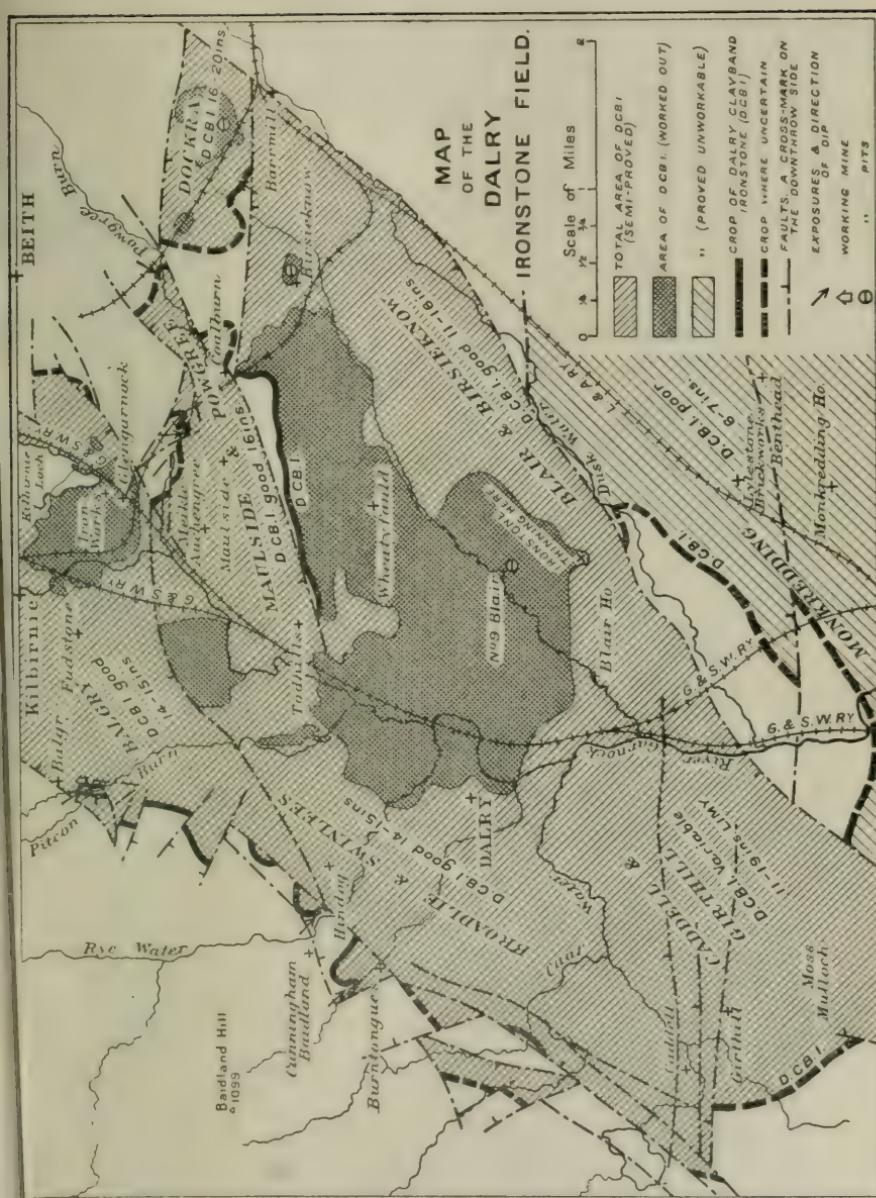


FIG. 3.—Geological Sketch-Map of the Dalry-Glengarnock Ironstone Field.

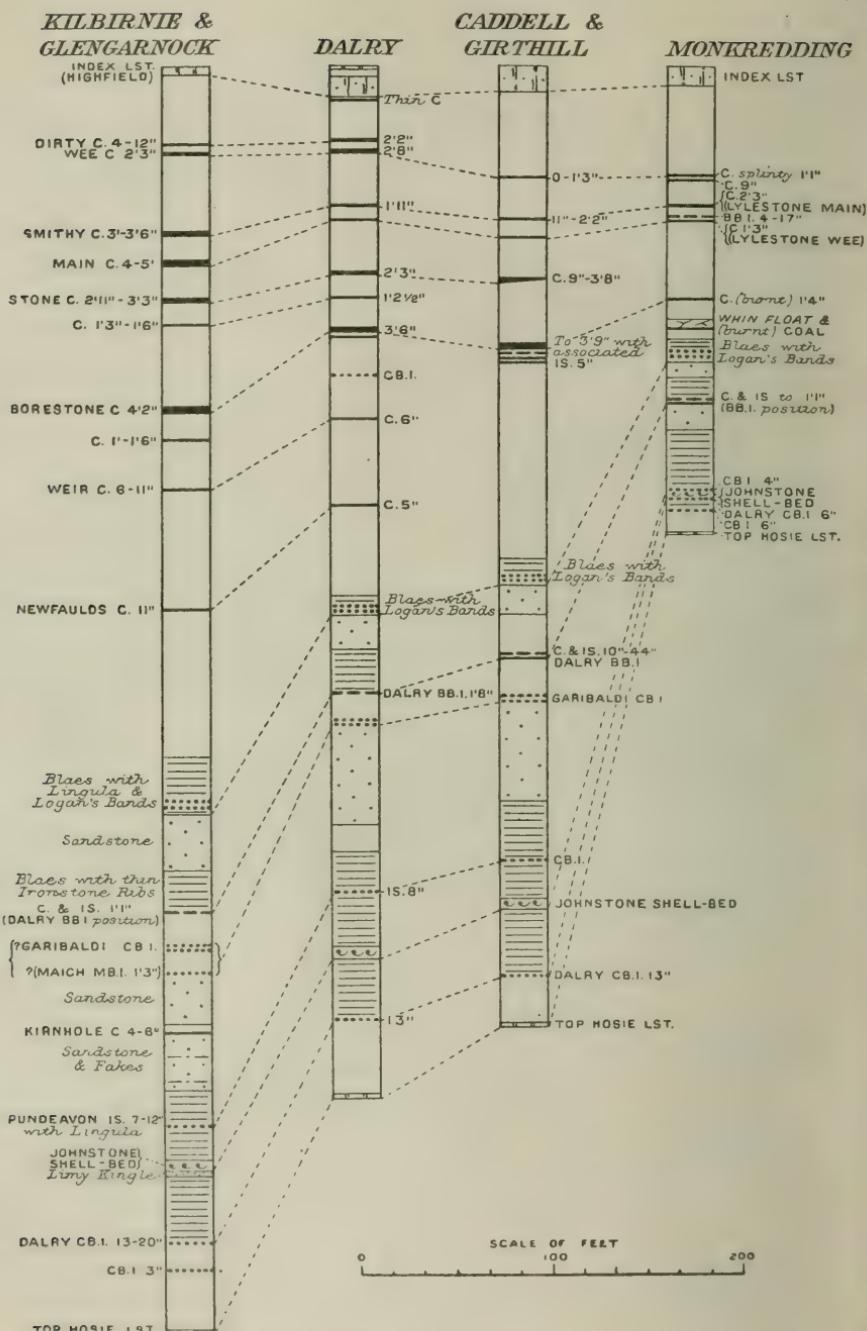


FIG. 4.—Comparative Vertical Sections of the Limestone Coal Group, N. Ayrshire.

C. = Coal.

IS. = Ironstone.

BB.I. = Blackband Ironstone.

CB.I. = Clayband Ironstone.

MB.I. = Musselband Ironstone.

LST. = Limestone.

	In.
Todhills No. 3 Pit	14
Highfield Nos. 2 and 5 Pits	13
Greenbank, Dalry, pit	12
Blair Pit	11-14
Girthill, old bore	11
" bore	11

(2) South of the line of the Dusk Water fault—

Lylestone, bore	6
Benthead, bore	6
Ardrossan, shore section	8

These localities are arranged more or less in geographical order, from north-east to south-west, and the figures given show a progressive thinning of the seam in that direction. They also indicate its poor development south of the Dusk Water fault, where it has never been proved of workable thickness. The quality of the iron-stone does not by any means remain constant throughout. It is richest in iron in the central portion of the district where the thickness averages 12 to 15 in. Where the seam is thicker than this it is usually much more calcareous, and, so far as our present knowledge goes, this is true also as regards the thinner portions.

Fig. 3 is a sketch-map of the Dalry-Glengarnock district, showing the outcrop of the Dalry Clayband and the area over which it is found. The map differentiates also those portions of the seam which have been worked out, and makes it clear that a very considerable field of ironstone still remains to exploit. The seam has been worked on an extensive scale between the River Garnock and the Dusk Water fault, over an area of several square miles. On the north side of the Garnock very little work has been done, and, apart from the Pitcon, Ryesholm, Mains and Glengarnock workings, the seam is practically untouched. At the present time the ironstone is raised at three pits, namely, Dockra, Birsieknowe and No. 9 Blair, and quite recently a mine has been opened in the seam at Balgry Farm, on the south side of the Gowkhouse Burn.* Over a large part of the unworked area, the Dalry Clayband is usually of suitable thickness and quality so that a more detailed account of its development locally is given below. The various ironstone fields mentioned can readily be found by reference to Fig. 3.

(1) *Kilbirnie, Balgry and Glengarnock*.—A large and practically untouched field exists here between the Pitcon and Pundeavon Burns. Its north-western boundary is formed partly by outcrop, partly by a fault which has a downthrow to the south. This fault runs from near the outcrop of the ironstone in the Paduff Burn, south-westwards through Balgry towards the Pitcon Burn, near the mouth of which the seam is again seen. On the south-east the field is defined by a large E.N.E. fault, and by the old workings of the Mains and Glengarnock Pits. The total extent of this field is about 2 sq. miles, and the average thickness of the ironstone is 15 in. A new mine, as already stated, has recently been opened up here from the outcrop in the Gowkhouse Burn,* and the stone, which

* Since the signing of the Armistice this mine has been abandoned, the iron-stone averaging only 13½ in.

occurs in two leaves, is taken to Glengarnock Ironworks. For analyses see p. 29.

(2) *Maulside and Powgree Burn*.—A considerable field of the Dalry Clayband exists to the south of Glengarnock, mainly on the lands of Maulside and Auchingree. The boundaries and extent of this field are shown approximately in Fig. 3. The clayband is exposed in a small field-drain on the south side of the Powgree Burn, immediately above the waterfall at Kersland Mill. The seam here dips to the south-east at an angle of about 15° , and is about 16 in. thick in three plies separated by thin blaes partings. The ironstone was formerly seen in the railway cutting near Whitestones, and is exposed again in the banks of the Powgree Burn, about 300 yds. down stream from the Barrmill and Beith branch railway, where it has a south-westerly dip. The Boestone Coal was formerly wrought in a small basin near Brackenhills Station, so that at that point the depth to the ironstone must be over 70 fms.

An analysis of the ironstone from Kersland Mill is given on p. 29.

(3) *Coalburn and Dockra*.—The positions of these two little basins are shown on the map on p. 25. The outcrop of the ironstone in the Coalburn basin just reaches the Powgree Burn about $\frac{1}{4}$ mile north-east of Coalburn. In the exposure on the south bank of the burn here the seam is about $16\frac{1}{2}$ in. thick in three ribs. The Dockra basin is situated near the branch railway to Beith, and the Dalry Clayband, as worked there at present, varies from 16 to 20 in. in thickness.

Only a small patch of about 40 acres exists in the Coalburn basin, but, so far as is known, the ironstone has never been worked here. In the Dockra field, on the other hand, a considerable area has been worked, as shown in Fig. 3. For an analysis of the iron-stone from Coalburn see p. 29.

(4) *Broadlie and Swinlees*.—This area, lying to the north-west of Dalry, is bounded on the north-east and south-west by the Pitcon Burn and the Caaf Water respectively, on the north-west by outcrop and by faulting, and on the south-east by the old workings of the Blair, Ryesholm and Pitcon Pits (see Fig. 3). The western part of the field is much disturbed by faulting, and in many places the metals are practically on end. Where exposed in the small stream at Burntongues, and again in a small tributary of the Rye Water, about $\frac{1}{2}$ a mile E.S.E. of Cunningham Baidland, the Dalry Clayband is 14 in. thick.

(5) *Blair and Birsieknowe*.—The ironstone has been wrought here to a large extent, and the available reserves are defined by old workings along the north-western margin of the field, and by the Dusk Water fault to the south-west (see Fig. 3). The seam varies greatly in thickness, being 16 in. at Birsieknowe Pit, and decreasing to 11 in. in parts of the Blair No. 9 Pit workings. Along the southern limits of these workings, and again where they approach the Dusk Water fault, the ironstone deteriorates very much, and is apparently already showing signs of thinning away. When picked up again to the south of the fault it is only 6 or 7 in. thick. For analyses of raw ore from Birsieknowe and of calcined ore from Blair see p. 29.

(6) *Caddell and Girthill*.—This field is taken as comprising the ground between the Caaf Water on the north, the outcrop of the seam to the west and the Dusk Water fault to the south-east. The section of the metals is given in Fig. 4. The outcrop of the iron-stone is not exposed, but its position can be inferred from exposures of the Johnstone Shell-bed and of the Lower Limestones. The former horizon can be seen in a small burn on the west side of the road-bridge from Muirlaught to Meikle Ittington. The ironstone varies from 11 to 19 in., and has been proved in several bores. Near Girthill it occurs at a depth of about 53 fms.

(7) *Monkredding*.—In this field, lying south-east of the Dusk Water fault, the whole of the Limestone Coal Group is reduced to a thickness of about 40 fms. (see Fig. 4). This reduction affects the coal and ironstone seams as well as the intervening strata, and so far as is at present known none of the ironstones are of economic value. The Dalry Clayband occurs over the whole area southwards from the crop, but is usually only 6 or 7 in. thick.

TABLE OF ANALYSES OF DALRY CLAYBAND FROM DALRY-GLENGARNOCK DISTRICT.

Number.	1.		2.		3.		4.	5.	6.	7.
	Raw.	Cal-cined.	Raw.	Cal-cined.	Raw.	Cal-cined.				
Remarks—										
Iron . .	29·17	41·42	28·81	40·69	25·73	37·00	27·09	24·12	25·06	39·87
Insoluble . .	11·20	...	13·50	...	...	...	16·70	13·70	...	...
Silica . .	9·30	13·20	10·30	14·55	7·62	11·11	11·50	10·00	8·45	13·90
Alumina . .	4·67	...	4·15	...	5·95	8·67	4·50	6·43	5·13	7·88
Phosphorus . .	0·56	0·793	0·55	0·777	0·56	0·81	0·698	0·656	0·53	0·97
Sulphur . .	0·073	...	0·087	...	0·23	0·34	0·192	0·189	0·25	0·188
Lime . .	7·33	10·41	7·56	10·67	12·92	18·84	8·72	12·64	11·41	10·08
Manganese Oxide . .	2·14	...	1·95	...	2·25	3·28	1·48	1·58	1·66	2·37
Magnesia . .	3·90	...	4·20	...	2·60	3·79	3·82	3·24	3·16	5·00
Loss on Ignition . .	29·60	...	29·20	...	31·43	...	28·50	29·80	35·21	...
Titanic Oxide . .	...	...	...	...	1·05	1·53	...	...	...	...
Moisture . .	...	...	...	...	...	...	0·47	0·315	...	...

Analysis No. 1. Gowkhous Burn, from new mine; top ply.

" No. 2. " bottom ply.

" No. 3. Paduff Burn, outcrop.

" No. 4. Powgree Burn, Kersland Mill outcrop.

" No. 5. Coalburn.

" No. 6. Birsieknowe Pit.

" No. 7. Blair No. 9 Pit.

Analysis No. 6 was kindly communicated by Messrs. Merry & Cuninghame Ltd., the others by Messrs. D. Colville & Sons.

Garibaldi Ironstone (or "The Bands" Ironstone).—This seam was worked at Glengarnock as recently as 1914, and appears to be a fairly constant horizon in the ground between that place and Dalry. It usually occupies a position from 2 to 5 fms. below the Dalry Blackband, and consists typically of thin clayband ribs separated by

partings of blaes; as many as thirteen such bands were cut at Glengarnock No. 6 Pit.* The total thickness of ironstone is by no means constant, but varies rapidly from 2 to 12 in. It occurs, in fact, rather as a series of "doggers" than as a definite seam.

This ironstone horizon has been worked on a limited scale mainly at Glengarnock Nos. 6 and 7 Pits; at No. 7 Pit the section is as follows:—

IRONSTONE (Top ^s)	5 in.
Blaes	12 "
IRONSTONE (Bottoms)	4 "

A small area of the stone was once worked from No. 4 Pit, Todhills, where the seam is found at a depth of 50 fms., and lies 5 fms. below the Dalry Blackband. In No. 10 Pit, Blair, the seam is 89 fms. deep, and is only 1 fm. under the Blackband. The section of the workings was as follows:—

	Ft	In.
COAL (BLACKBAND position)	0	9
Blaes, roof	4	0
IRONSTONE	0	3
Blaes	0	8
IRONSTONE	0	3
Blaes, pavement		

The information available regarding this seam shows that a considerable area of it probably exists between Glengarnock and Dalry. The following table shows the thickness and depth of the Garibaldi Ironstones at various localities.

Locality.	Thickness.	Depth.
Glengarnock (Lochend Pits)	Three ribs of 5, 9 and 5 in., in 6 ft. of blaes	65 fms.
Wheatyfauld	Two ribs, 6 in. each, in 1 ft. of blaes . . .	72 "
Fudstone Farm	Three ribs of 1½, 6 and 3 in., in 4 ft. 9 in. of blaes	37 "
Holmhead	Two ribs of 6 and 4½ in., in 15 in. of blaes . . .	45 "
Paddock Holm	Two ribs of 2 and 5 in., in 4 ft. of blaes . . .	23 "
Todhills No. 2 Pit	Two ribs, 6 in. each, in 2½ ft. of blaes . . .	50 "
" No. 4 Pit	... . . . .	26 "
Blair No. 10 Pit	Two ribs, 3 in. each, in 14 in. of blaes . . .	50 "
		89 "

When the Dalry Clayband is opened out in this district, the Garibaldi Ironstones will no doubt be exploited at the same time, where found of sufficient thickness to work. As the figures given above show, however, they are very variable and not likely to attract attention in themselves.

The following average analysis of the Garibaldi seam from Glengarnock No. 6 Pit illustrates the rich nature of the ore. The analysis has been kindly communicated by Messrs. D. Colville & Sons.

* It is doubtful, however, if all these occurred below the Dalry Blackband.

	Per cent
Iron	47·54
Silica	11·30
Alumina	5·77
Phosphorus	0·55
Sulphur	0·16
Manganese Oxide	1·30
Lime	7·50
Magnesia	3·50

The Garibaldi horizon has not been recognised to the south-east of the Dusk Water Fault.

Dalry Blackband.—The Dalry Blackband was formerly worked on an extensive scale in the Dalry district. For all practical purposes, however, the field may now be considered exhausted.

The only good exposure of the seam occurs on the east side of the Rye Water (in that part known as Hindog Glen), just below Cunningham Baidland (Ayr, 7 S.E.). Only the top part of the blackband can be seen, the remainder being under water. The general section, as obtained from the old mining plans, is as follows:—

	Ft. In.
Blaes roof	
BLACKBAND { TOPS	0 2
IRONSTONE, { MIDS	0 6
18 in. { BOTTOMS	0 10
Fireclay	1 4
Blaes pavement	

The following table illustrates the variations in thickness and character of the seam:—

Flashwood No. 1 Pit (Dalry)	Blackband, 18 in.
Kilbirnie No. 35 Pit, near the Pitcon Burn	16 "
Kilbirnie Loch Pits	{ Blackband, 12 "
	{ Coal, 7 "
	{ Blackband, 2 "
Glengarnock No. 3 Pit	{ Blackband, 10 "
	{ Coal, 6 "

In some parts of the Dalry field the ironstone is entirely replaced by volcanic ash. This is well shown on the old mining plans of the district. In other cases the seam was so split up by thin layers of ashy sediment as to be unworkable. At the time of the deposition of the iron pyrite carbonaceous material, now consolidated into what we know as the Dalry Blackband, it would seem as if the area around Dalry had been a low-lying, swampy plain whose surface was dotted with the cones of small active volcanoes of the explosive type. These cones were apparently mainly built up of fairly fine-grained and highly ferruginous ash, whose iron contents may, in part at least, have served to enrich the waters of the old swamp.

Elsewhere within this district the Dalry Blackband is thin and poor in quality, and is often represented by a thin coal associated with a few inches of ironstone. At Lylestone, for example, on the south side of the Dusk Water fault, the blackband varies from 0 to 4½ in., and is usually accompanied by a coking coal 6 to 12 in. thick. Occasionally the ironstone is a true blackband, but sometimes it is

more of the nature of a clayband. An analysis gave iron 38 per cent., coal matter 6 per cent.

Logan's Bands.—These ironstones, although persistent over the whole area, vary considerably in thickness and quality. Where seen in the Paduff Burn (see Kilbirnie-Lochwinnoch district, p. 23) they are quite good in character, but as exposed in the small burn just west of Swinlees House the ironstones are thinner and farther apart. At one time an attempt was made to work these bands at Ryesholm Colliery, but very little seems to have been done. The section of the working was as follows:—

			Fms.	Ft.	In.
Blaes roof			4	0	0
1ST IRONSTONE			0	0	6
Blaes			0	0	1
2ND IRONSTONE			0	0	4
Blaes			0	1	5
3RD IRONSTONE			0	0	4
Blaes			0	1	6
4TH IRONSTONE			0	0	6
Blaes pavement			0	3	0

A bore near Dalry gave 28 in. of ironstone in 12 ft. of blaes at a depth of 73 fms. The same horizon has been recognised in the Girthill field, where 13 in. of ironstone occur in about 4 fms. of blaes.

Other ironstone seams found locally at higher horizons:—

Girthill.—A seam of ironstone of a blackband nature has been noticed in the course of a pipe-track near Meikle Laught. The exact geological position of this seam has not yet been ascertained, but it appears to be associated with a 12-in. coal. Two, and possibly three, ironstone bands were noted, varying in thickness from 4 to 7 in.

Lylestone.—An exceedingly variable ironstone occurs about 2 ft. above the Lylestone Wee Coal. The average thickness is about 6 in., but occasionally as much as 17 in. was noticed. Near High Gooseloan two seams occur, the upper one lying $2\frac{1}{2}$ ft., the lower one 16 in., above the coal. The analyses * of these two seams show:—

		Upper.	Lower.
Iron	%	31·86	32·63
Silica	%	13·20	13·53
Alumina	%	10·16	8·69
Lime	%	2·32	2·30
Magnesia	%	1·44	1·48
Sulphur	%	0·05	0·15
Phosphorus	%	0·47	0·57
Loss on calcination	%	30·57	31·09
Iron in calcined stone	%	43·88	45·05

* Kindly communicated by H. King, Esq., Kilwinning. Analysed by Dr. Wm. Wallace, Glasgow.

ESTIMATED RESERVES IN THE DALRY-GLENGARNOCK AREA.

Name of Seam.	Average Thickness.	Area.	Reserves in Tons.	
			Probable.	Possible.
Logan's Bands . . .	20 in. in a 4-ft. 8-in. working.	9 sq. miles.	...	24,750,000
Dalry Blackband—worked out for all practical purposes.				
Garibaldi Claybands . . .	Bands varying from 2 to 12 in.	About 4 sq. miles.	...	5,000,000
Pundeavon Ironstone . . .	9-13 in.	Unknown.	Probably	Little.
Dalry Clayband . . .	11-20 in.	About 13 sq. miles.	38,500,000	...

Kilwinning and Kilmarnock.

Six-inch Ordnance and Geological Survey Sheets :—
Ayr, 16 N.W., N.E., S.E.; 17; 18.

Practically all the workable ironstones here belong to the Productive Coal Measures, and are chiefly of the nature of blackbands. They are dealt with later on pp. 37-9. Of the character and extent of the ironstones in the Limestone Coal Group, on the other hand, very little information is available.

(1) *Ardrossan and Ardeer*.—This is practically the only part of the wide area here dealt with where anything is known as to the condition of the ironstones of the Limestone Coal Group. The Dalry Clayband is probably represented by an 8-in. seam exposed on the shore near Castle Craigs, Ardrossan. A clayband ironstone was formerly worked at Laigh Dykes Pit (Ayr, 16 N.W.), but its geological horizon is not exactly known. Some details obtained from two old bores near Laigh Dykes are given below :—

No. 1 bore.	In.	No. 2 bore.	In.
WHITE IRONSTONE . . .	6½	IRONSTONE (BLACKBAND) . . .	11
Blaes . . .	8	Blaes . . .	18
WHITE IRONSTONE . . .	6	IRONSTONE (CLAYBAND) . . .	14
Blaes . . .	5	Blaes . . .	11
WHITE IRONSTONE . . .	5 at 29 fms.	IRONSTONE (CLAYBAND) . . . at 7½ fms.	7

The seams shown in No. 1 bore probably occur somewhere near the position of the Dalry Clayband. Those in No. 2 bore are very likely the seams worked at Laigh Dykes, and may be the equivalent either of Logan's Bands or of the Dalry Blackband and underlying Garibaldi Claybands.

(2) *Kilwinning-Kilmarnock Field*.—Our knowledge of the Limestone Coal Group, as developed in the country between these places, is very scanty. Such evidence as is available tends to show that the associated ironstones are of little economic value. This holds true also of the area along the southern border of 1-in. Sheet 22 between Galston and Symington.

East of Kilmarnock again the seams appear to be thickening, and in this connection the following details from a boring at Newhouse Farm (Ayr, 18 S.W.), about 2 miles east of the town, may prove of interest:—

			Thickness.			Depth from Surface.		
			Fms.	Ft.	In.	Fms.	Ft.	In.
CLAYBAND .	.	.	0	0	5	110	0	8
Blaes .	.	.	0	2	7			
(A) CLAYBAND .	.	.	0	0	8	110	3	11
Blaes .	.	.	0	1	10			
(B) CLAYBAND .	.	.	0	0	6	111	0	3
Blaes .	.	.	0	2	1			
(C) MUSSELBAND IRONSTONE .	.	.	0	0	9	111	3	1
Fakes and blaes .	.	.	1	4	6			
(D) CLAYBAND .	.	.	0	0	8	113	2	3
Blaes .	.	.	1	3	11			
CLAYBAND .	.	.	0	0	4	114	0	6
Blaes .	.	.	1	1	0			
CLAYBAND .	.	.	0	0	6	115	2	0
Blaes .	.	.	1	0	0			
CLAYBAND .	.	.	0	0	6	116	2	6
Faky blaes .	.	.	0	4	10			
COAL .	.	.	0	0	8	117	2	0
Strata, mainly blaes .	.	.	5	4	0			
CLAYBAND .	.	.	0	0	4	123	0	4
Blaes .	.	.	1	1	8			
CLAYBAND .	.	.	0	0	2	124	2	2
Blaes .	.	.	0	2	2			
CLAYBAND .	.	.	0	0	8	124	5	0
Blaes .	.	.	0	4	6			
SHELLY BLAES .	.	.	1	5	0	127	2	6
Blaes .	.	.	0	0	6			
(E) CLAYBAND .	.	.	0	0	8	127	3	8
Blaes .	.	.	1	1	10			
(F) CLAYBAND .	.	.	0	0	11	129	0	5
Blaes .	.	.	1	1	1			
CLAYBAND .	.	.	0	0	5	130	1	11
Fakes and blaes .	.	.	4	4	11			
CLAYBAND .	.	.	0	0	3	135	1	1
Fakes and blaes .	.	.	2	2	8			
(G) IRONSTONE .	.	.	0	0	9	137	4	6
Faky blaes .	.	.	0	1	6	138	0	0

The correlation of these seams with those of the Dalry field is not easy, but the following suggestions may be made. The first three claybands may correspond in position to the Dalry Blackband, while the musselband ironstone below them is most probably the equivalent of the Maich Musselband of Kilbirnie (see p. 21). The shelly blaes at 127½ fms. is in all likelihood the Johnstone Shell-bed, so that the Dalry Clayband would be represented by one or all of the ironstone ribs below it.

The analyses* of the ironstones marked A-G are shown in the following table:—

* For these we are indebted to Messrs. M'Lauchlan & Geddes, 21 Young Street, Edinburgh.

	A.	B.	C.	D.	E.	F.	G.
	Calcined.	Raw.	Calcined.	Raw.	Calcined.	Raw.	Calcined.
Iron .	%	%	%	%	%	%	%
	39·6	28·8	38·5	26·7	50·3	31·8	40·3
Insoluble .	23·1	16·85	23·8	18·5	9·2	5·85	25·5
Silica .	16·5	12·0	15·4	10·6	6·4	4·1	18·8
Lime .	4·5	3·3	7·5	5·2	9·1	5·8	3·0
Manganese	1·7	1·29	1·8	1·29	2·0	1·29	1·0
Phosphorus	0·813	0·591	0·806	0·559	0·927	0·558	0·521
Carbon .	...	2·8	...	6·2	...	3·3	4·3

Cumnock, Lugar and Muirkirk.

For the 6-in. Ordnance and Geological Survey Sheets and for a short general account of the district see pp. 44-6.

In the Muirkirk field several clayband ironstones were formerly wrought along their outcrops, but were abandoned after the discovery of the Lugar Blackband. The general section of the Limestone Coal Group from the Nine-foot Coal to the Macdonald Limestone is as follows:—

		Fms.	Ft.	In.
NINE-FOOT COAL .	.	1	2	0
Strata .	.	3	0	0
HIGH-BAND IRONSTONE .	.	0	1	2
Strata .	.	5	0	0
MID-BAND IRONSTONE .	.	0	1	3
Strata .	.	0	4	0
THIRTY-INCH COAL .	.	0	2	6
Strata .	.	6	4	0
CATCHYBURN COAL .	.	1	0	0
Strata .	.	11	1	0
LOW-BAND IRONSTONE .	.	0	1	0
Strata .	.	1	4	0
MACDONALD COAL .	.	0	5	0
Strata .	.	2	0	0
MACDONALD IRONSTONE .	.	0	1	2
Strata .	.	0	2	0
LIMESTONE (Top Macdonald = Top Hosie)	.	1	0	0

For the equivalents of these seams in the Lanarkshire and the N. Ayrshire sequence see the notes given on p. 55.

Of the ironstones mentioned the Mid-band and Low-band seams appear to have been the most productive and the best in quality. The High-band was of a more siliceous nature. The better ironstones contained from 30 to 35 per cent. of iron, and were worked along their outcrops from near Wellwood Burn to just beyond Catchyburn, $1\frac{1}{2}$ miles farther east. As the workings were continued to the dip the seams decreased in thickness, and some of them degenerated into bands of ironstone balls. There is little prospect of these ores being again worked in the near future.

An ironstone associated with the Nine-foot Coal was worked to a small extent near Wellwood.

About 6 miles to the W.S.W., the Limestone Coal Group is again exposed in the sides of the Gass Water. So far, however, only one definite seam of ironstone has been recognised here. It is about 10 in. thick, and was formerly worked on a small scale on the west side of the Gass Water near the old railway to Dalfad Moss. Farther west, near Lugar and Cumnock, the Limestone Coal Group is not exposed at the surface and has so far not been proved by boring. In the country to the north of Sorn, where the same group of rocks again outcrops, it is not known to contain ironstones of any value.

ESTIMATED RESERVES IN MUIRKIRK FIELD.

(The Mid-band and the Low-band need alone be considered.)

Name of Seam.	Average Thickness.	Area in Acres.	Possible Reserves.
Midband : .	15 in.	2,000	9,000,000
Lowband : .	12 „	2,400	8,640,000

COAL MEASURES.

The reasons which led in the case of the Limestone Coal Group (see p. 17) to the adoption of geographical units as a basis for the detailed account of the ironstones, apply equally strongly in the case of the Coal Measures. The districts chosen for separate description are as follows:—

Kilwinning and Kilmarnock.
Dalmellington. (See Fig. 5.)
Cumnock, Lugar and Muirkirk. (See Fig. 6.)

Kilwinning and Kilmarnock.

For six-inch Sheets see p. 33.

This area comprises the wide extent of Coal Measure rocks in the southern part of 1-inch Sheet 22. Their northerly extension is limited by their outcrops, and their boundary to the south is defined by the large fault which runs from near Galston in a west-south-west direction towards Dundonald. The ironstones worked within this area all occur near the base of the Coal Measures.

(1) *Ardrossan and Ardler Field.*—No Coal Measure ironstones have as yet been wrought here, but several iron ribs and musselband ironstones are known to occur a few fathoms below the Wee Coal. The section is as follows:—

	Fms. Ft. In.
WEE COAL . . . . .	. 0 1 10
Strata . . . . .	. 4 0 0
MUSSELBAND . . . . .	. 0 0 4
Fakes . . . . .	. 0 5 0
IRONSTONE RIB . . . . .	. 0 0 6
MUSSELBAND . . . . .	. 0 0 9
Blaes . . . . .	. 0 0 9
IRONSTONE RIB . . . . .	. 0 0 9
Fakes . . . . .	. 0 4 0
IRONSTONE RIB . . . . .	. 0 0 4
Fakes . . . . .	. 0 0 2
MUSSELBAND . . . . .	. 0 1 0
IRONSTONE RIB . . . . .	. 0 1 0

An analysis of one of the musselbands gave the following result for the calcined stone:—

	Per cent.
Iron . . . . .	. 42·30
Silica . . . . .	. 11·40
Phosphorus . . . . .	. 2·03

The extent of these ironstones is not known, but a considerable area could be easily proved by a series of shallow bores put down parallel to, and on the side of, the road from Saltcoats to Stevenston.

(2) *Moncur and Lugton Water Field.*—In this field lying to the east of Kilwinning, no Coal Measure ironstones have so far been exploited. A musselband ironstone, which occurs between the Kilwinning Main and Stone coals, may perhaps be worth attention.* The following section of this horizon is to be seen in the south bank

* See table of Ayrshire ironstone reserves given on p. 48.

of the Lugton Water, about 200 yards downstream from Sevenacres Bridge :—

		Ft.	In.
Blaes . . . . .	.	1	0
IRONSTONE . . . . .	.	0	3
COAL (? STONE COAL) . . . . .	.	0	7
Gap . . . . .	.	18	0
Faky sandstone . . . . .	.	6	0
Fakes . . . . .	.	0	4
Blaes . . . . .	.	0	9
Coaly blaes with small ironstone nodules . . . . .	.	1	0
MUSSELBAND and PARROT COAL . . . . .	.	1	4
BRIGHT COAL . . . . .	.	0	7
Fireclay . . . . .	.	3	0

An analysis of the Musselband (kindly communicated by Messrs. D. Colville & Sons, Glengarnock) gave the following result :—

		Raw.	Calcined.
		Per cent.	Per cent.
Iron		30·78	55·36
Silica		2·50	4·61
Alumina		2·70	4·00
Magnesia		1·90	3·40
Lime		2·10	3·86
Manganese oxide		1·76	3·01
Titanic oxide		Nil	Nil
Phosphorus		0·20	0·35
Sulphur		0·37	0·60
Loss on calcination		44·75	...

The extent of the seam is fairly large, and its occurrence has been proved in a number of bores near High Moncur, about half a mile south-west of the Lugton Water section. The following details are given by way of illustrating its development there :—

Name and Number of Bore.	Particulars of Seam.	Depth from Surface.					
		Ft.	In.	Fms.	Ft.	In.	
Moncur Diamond Bore No. 20 . .	Black fakes	2	3	...			
	MUSSELBAND	2	9	...			
	Black slit	1	0	...			
	COAL	0	7	18	3	1	
Moncur Diamond Bore No. 21 . .	DARK MUSSELBAND	0	10				
	CLEAN COAL	1	6	17	2	5	
Moncur Diamond Bore No. 22 . .	Black blaes	0	7	...			
	MUSSELBAND	0	5	...			
	PARROT COAL	0	3	...			
	IRONSTONE	0	4	...			
	COAL	0	11	18	3	9	

These bores are in 6-in. Sheet Ayr, 12 S.W., and are close together.

(3) *Annick Lodge* (Ayr, 17 N.W.).—An ironstone associated with the Kilwinning Main Coal was worked here on a small scale about 1890. The stone is grey in colour, and looks more like a "kingle" than an ironstone. The section of the seam in the workings was as follows:—

	Ft. In.
Sandstone roof	
Fakes	2 0
IRONSTONE	1 3
COAL	1 0
Fireclay pavement	

The workings were abandoned on account of the sulphurous nature of the ore.

This ironstone is irregular in its occurrence. At Warwick Lodge it is found along with a 6-ft. post of freestone as a parting in the Kilwinning Main Coal. A fair area has been proved along the railway line between Montgreenan and Cunningham Head Stations, and from thence southwards to Warwick Lodge.*

(4) *Busbie and Southook* (Ayr, 17 N.E., S.E.).—The *Plann Ironstone*, which occurs at a height of 1–4 fms. above the Ell Coal, has been worked extensively in this field. The seam is a blackband ironstone associated with a fireclay and a coal. The section in the Southook Pits averaged:—

	Ft. In.
Blaes roof	
IRONSTONE (BLACKBAND)	0 9
Fireclay	0 2
COAL	0 4
Faky blaes pavement	

An analysis of the stone shows:—

	Per cent.
Iron	31·51
Silica	2·70
Alumina	1·46
Magnesia	2·41
Manganese oxide	0·90
Lime	4·12
Phosphorus	0·23
Sulphur	0·23
Coaly matter	17·00
Carbon dioxide	31·00

The better portions of the seam are now worked out, but a fair quantity of the stone, averaging 9 in. in thickness, still exists over an area of about a square mile in the neighbourhood of Annandale Colliery.†

An analysis of the seam as worked at Busbie by Messrs. Jas. Dunlop & Co. Ltd. of Clyde Iron Works, has been kindly communicated by that firm:—

	Calcined. Per cent.
Iron	41·79
Insoluble	17·99
Lime	5·68
Phosphorus	0·53
Sulphur	0·70

* See table on p. 48.

† See table on p. 48.

Dalmellington.

Six-inch Ordnance and Geological Survey Sheets :—
Ayr, 40 ; 41 N.W., S.W. ; 46.

The workable ironstones of the Dalmellington district (see Fig. 5) occur in the Productive Coal Measures which occupy here an area of about 40 square miles. On the south-west this field is bounded partly by outcrop, partly by faulting along a line which practically follows the course of the River Doon from Patna to the south end of Bogton Loch. The north-west margin is defined by the large boundary fault which runs from near Girvan past Kirkmichael, crosses the River Doon about $1\frac{1}{2}$ miles below Patna, and continues in a north-easterly direction past Cumnock towards Muirkirk. On the north the boundary of the area has been arbitrarily drawn at the northern margins of the six-inch Sheets 40 and 41. On the south-west, again, the Carboniferous rocks are faulted against strata of Old Red Sandstone age along a line which runs from near Dalmellington north-eastwards to Craighouse, where it turns in an east-north-easterly direction to cross the River Nith about halfway between New Cumnock and Kirkconnel.

The section of the Dalmellington metals, as given by Dron in his "Coalfields of Scotland." * is appended :—

		Fms.	Ft.	In.
COAL .	.	0	0	10
Strata	.	16	0	0
COAL .	.	0	1	6
Strata	.	18	0	0
COAL .	.	0	3	6
Strata	.	1	3	0
CRAIGMARK IRONSTONE .	.	0	1	6
Strata	.	4	0	0
COAL .	.	0	3	0
Strata	.	11	3	0
COAL .	.	0	4	0
Strata	.	6	0	0
COAL .	.	0	1	9
Strata	.	7	0	0
COAL .	.	0	2	6
Strata	.	13	3	0
SILLYHOLE COAL .	.	1	0	0
Strata	.	6	3	0
COAL .	.	0	2	0
Strata	.	16	0	0
DIAMOND COAL .	.	0	4	6
Strata	.	18	0	0
CHALMERSTONE COAL .	.	0	5	0
Strata	.	12	0	0
MINNEVEY COAL .	.	0	4	6
Strata	.	14	4	0
SLOANSTONE COAL .	.	0	3	6
Strata	.	18	2	0
COAL .	.	0	1	11
Strata	.	9	0	0
COAL .	.	0	2	9
Strata	.	4	0	0
MUSSELBAND IRONSTONE .	.	0	1	0
Strata	.	2	0	0
CAMLARG COAL .	.	0	4	4
Strata	.	4	3	0

* 1902, p. 67.

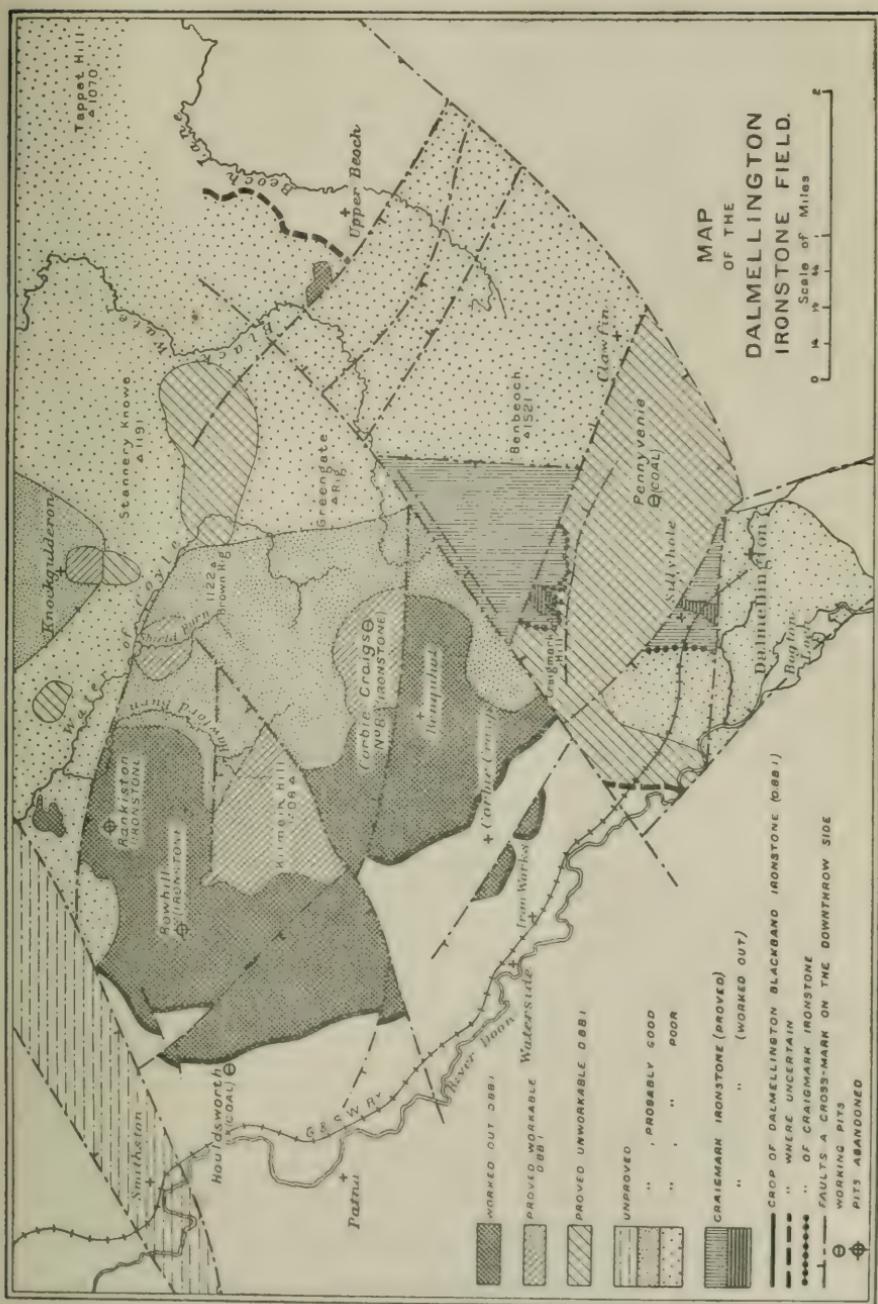


FIG. 5.—Geological Sketch-Map of the Dalmellington Ironstone Field.

		Fms.	Ft.	Ins.
COAL		0	3	0
Strata		18	0	0
UPPER COKING COAL		0	2	6
Strata		7	3	0
PENNYVENIE SPLINT COAL		0	3	8
Strata		9	1	0
LOWER COKING COAL		0	3	11
Strata		11	0	0
MUSSELBAND IRONSTONE		0	0	4
Strata		3	0	0
DALMELLINGTON BLACKBAND		0	2	3

The Dalmellington field is much broken by faults of which there appear to be two main systems, the one N.E.-S.W., the other N.W.-S.E. The large fault which runs south of Smithstone north-eastwards towards Rankinston has near Patna a downthrow to the north-west of about 250 fms. Besides the complicated system of faulting, the field is riddled with volcanic intrusions.

Two ironstones have been worked in this district, namely, the Dalmellington or Burnfoot Blackband and the Craigmark or Palacecraig Ironstone.*

Dalmellington Blackband.—This is the most important ironstone of the district, and has been worked on an extensive scale for a large number of years. It is taken as the local base for the Coal Measures, and correlated roughly with the Slatyband of Lanarkshire.† It consists essentially of irregular layers of dark-grey ironstone in a carbonaceous matrix. The thickness varies greatly; in the best parts of the field the bed was 30 to 40 in. thick, but east of Dalmellington it deteriorates in quality, and is represented by a few thin iron ribs in about 10 ft. of carbonaceous blaes. At the present time only one pit (Corbie Craigs No. 8) is working the ironstone, and herè difficulties in mining it have arisen through the presence of a volcanic neck, so that no ore is being actually produced. The stone was usually calcined in open hearths near the pits, and the char taken down to the furnaces by rail.

From a rough calculation it appears that about 8 to 10 million tons of blackband ironstone must have been raised from this horizon. The Rankinston mines were worked by Messrs. Merry & Cuninghame for the Ardeer furnaces. These pits closed about three years ago, and boring operations in the neighbourhood did not prove any great addition to the known field, although the value of these bores may be largely discounted owing to their proximity to lines of fault. The small working near Beoch is of old date, and was the property of the New Cumnock Iron Co., who at one time took the ore to their furnaces at New Cumnock.

The general distribution of the Dalmellington Blackband is shown in Fig. 5, where some attempt has also been made to indicate the probable condition of the seam throughout the district. From examination of the map it is clear that large areas of the Dalmellington Blackband are as yet unproved, and as it is just these areas that are of most interest from an economic point of view, a rather more detailed account of them is necessary.

In the north-west corner of the map there is an unproved area

* For approximate estimate of reserves see table on p. 48.

† See p. 110.

lying between the two almost parallel N.E. faults. The throw of both of these faults is very large; the more northerly one, throwing beds well up in the Coal Measures against Calciferous Sandstone strata, must be from 350 to 450 fms. in magnitude, while the one to the south has a proved throw of 250 fms. An old pit near Smithstone worked the Chalmersome Coal at a depth of 40 fms., and as this seam lies about 120 fms. above the Blackband, the latter at the same locality must be approximately 160 fms. deep. Higher coal seams come on to the east of Kerse Loch, so that in this direction the position of the ironstone will be found at correspondingly greater depths. Since, however, the two faults both trend inwards towards the unproved field of ironstone, its extent will be considerably less at the depth at which it occurs. It is upon the whole doubtful if mining operations would be undertaken here unless the blackband proved of exceptionally good thickness and quality.

Considering next the large roughly triangular and practically unproved area lying between Rankinston, Clawfin and Tappet Hill, we find little available information about the possible ironstone reserves. Very little boring has been done, but from the general character of the blackband in the Rankinston, Bowhill and Corbie Craigs workings, and from the fact that small areas of workable stone have been proved east of Bowhill, north-east of Benquhat, and again on the east side of Shields Burn, it seems quite likely that a workable field may still exist in the area between the Hawford Burn on the west, the Water of Coyle on the north and east, and the edge of the Corbie Craigs workings near Benquhat. Farther east in the old workings near Beoch the quality of the stone does not appear to have been good. The same is probably the case near Tappet Hill, since the seam apparently deteriorates as it is traced north-eastwards towards New Cumnock, where it consists only of pyritous blaes. It does not seem likely that the quality will be any better to the south of Beoch; near Pennyvenie the horizon is known to consist of about 10 ft. of coaly blaes with a few iron ribs.

Very little is known of the quality of this ironstone in the area between the River Doon and the Sillyhole fault. In a bore near Laight Cottage it was only 4 in. thick. Finally, as regards the area near Bogton Loch, nothing is known of the ironstone except that it must be about 250 fms. deep.

Analyses of Dalmellington Blackband.*

(1) No. 8 Pit, Corbie Craigs. (2) Bowhill Pit. (3) Rankinston.

	1.		2.		3.
	Raw.	Calcined.	Raw.	Calcined.	Raw.
Iron	32.55	46.07	27.82	46.30	35.64
Silica	14.70	8.88	14.90	11.75
Lime	5.90	2.46	4.10	1.32
Manganese oxide	0.55	0.93	1.35
Phosphoric acid	0.54	...	...	0.78
Sulphur trioxide	0.15	...	...	0.17
Insoluble	19.10	...	...	...
Loss on ignition	40.0	...	40.25
Water	1.32	...	0.75
Alumina	7.4

* Nos. 1 and 2 communicated by the Dalmellington Iron Co., No. 3 by Messrs. Merry & Cuninghame.

Craigmark Blackband.—This ironstone occurs near the top of the Coal Measures of this district, about 210 fms. above the Dalmellington Blackband. It occupies a somewhat similar position to the Palacecraig Blackband of the Lanarkshire sequence, and is sometimes known under that name.

The section of the seam, as proved in bores, shows approximately—

Parrotty blaes	6 or 7 in.
BLACKBAND	12 or 14 in.
COAL	10 in.

It has been worked to a limited extent near its outcrop on Craigmark Hill. These workings terminated rather abruptly to the north, and it was thought that only a small field of ironstone existed. Recent bores have, however, proved the existence of a downthrow fault to account for the barren area met with in the old workings, with the result that a considerable area of the stone is as yet untouched (see Fig. 5).

This seam has also been worked on a small scale to the south of the Sillyhole fault. These workings are probably cut off to the south by a fault running almost east-and-west, and south of this fault nothing is known of the ironstone, although a small area of workable stone may occur in the east of the district near Bell's Bank.

An analysis of the Craigmark Blackband, communicated by the Dalmellington Iron Co., shows:—

	Raw.	Calcined.
	Per cent.	Per cent.
Iron	15·99	44·22
Silica	6·43	17·84
Lime	1·15	3·30
Phosphorus	0·18	0·50
Sulphur	0·95	0·205
Magnesia	0·91	2·52
Carbon dioxide	13·23	Note.—These analyses are from different samples.
Organic matter	50·29	
Moisture	1·93	

In the New Cumnock area the seam is said to be represented by a parrotty shale.

It is difficult to say at present if the Craigmark Ironstone is likely to be worked in the near future. The percentage of iron in the calcined ore, in relation to the insoluble material, is not very high. On the other hand, the overlying parrotty blaes might possibly be found of use as a source of oil and sulphate of ammonia.

For approximate estimate of reserves, see table on p. 48.

Cumnock, Lugar and Muirkirk.

Six-inch Ordnance and Geological Survey Sheets:—Ayr, 29; 30; 31 N.W., N.E., S.W.; 35; 36 N.W., S.W.

The area dealt with here (see Fig. 6) extends westwards from Glenbuck and Muirkirk through Lugar and Cumnock to beyond

Auchinleck, near which place the Carboniferous rocks are covered by the New Red Sandstone of the Mauchline basin. Its northern margin is defined by a series of east-and-west faults, its southern margin partly by faulting and partly by outcrop. In the southern

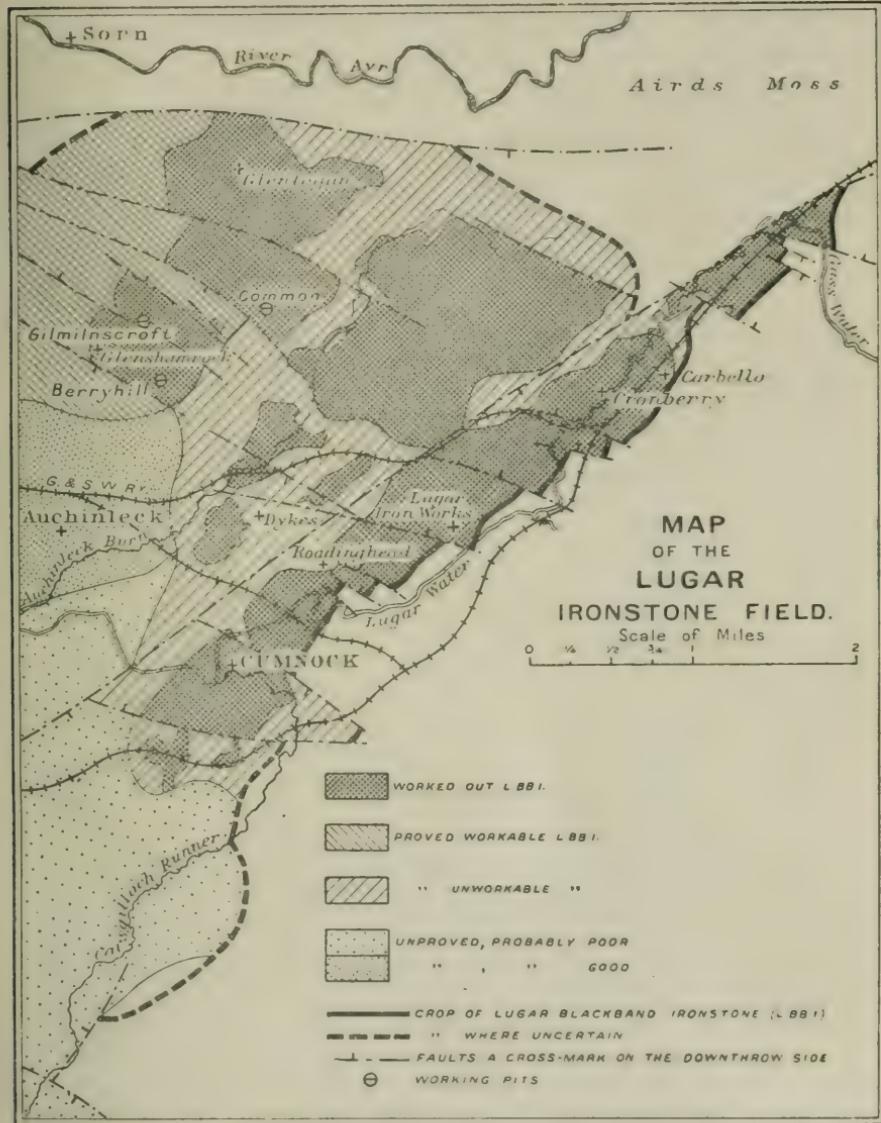


FIG. 6.—Geological Sketch-Map of the Lugar Ironstone Field.

part of the field the strata are generally inclined to the north-west, while near Glenlogan again the dip is to the south-east. Thus, a distinct syncline occurs between the outcrop near Sorn and that near Lugar. In addition to being folded, the area is much disturbed by a system of N.N.W. faults, which here and there have displacements of 40, 50, or even 80 fathoms. An important line of faulting also

crosses the field in a north-easterly direction. This dislocation, which near Lugar has a downthrow to the south of about 50 fms., is marked by great disturbance of the metals which in places are practically vertical for a distance of at least 300 yds. from the line of fracture. It can be traced from near Muirkirk to well beyond Cumnock, and is probably continuous with the large north-east fault mentioned as occurring to the north of Patna (see account of Dalmellington district, p. 40).

In many parts of this area, particularly to the north and north-west of Lugar, the ironstone has been rendered useless owing to the intrusion of a great sill of basic igneous rock.

The general succession in the Cumnock-Lugar district is shown in the following table :—

		Fms.	Ft.	In.
ELL	COAL	.	0	3 9
	Blaes	.	0	2 0
	COAL	.	0	1 8
	Strata	.	8	3 0
MAIN COAL	.	.	0	5 0
	Strata	.	5	0 0
DIRTY COAL	.	.	0	3 0
	Strata	.	28	0 0
COAL	.	.	0	1 0
	Strata	.	3	0 0
COAL	.	.	0	1 4
	Strata	.	6	0 0
CLAUD COAL	.	.	0	2 0
	Strata	.	7	0 0
MAID COAL	.	.	0	4 0
	Strata	.	1	0 0
LOW MAID COAL	.	.	0	3 11
	Strata	.	51	0 0
17-FATHOM COAL	.	.	0	2 0
	Strata	.	8	0 0
10-FATHOM COAL	.	.	0	1 2
	Strata	.	2	3 0
7-FATHOM COAL.	.	.	0	0 6
	Strata	.	7	0 0
LUGAR BLACKBAND IRONSTONE	.	.	0	1 4

Lugar Blackband Ironstone.—This seam apparently occupies a similar geological position to the Dalmellington Blackband, *i.e.* it lies near the junction of the Coal Measures with the Millstone Grit Series. It has been wrought extensively between Cumnock, Lugar and Glenlogan, and farther to the north-east again smaller areas of the seam have been opened out on the south and downthrow side of the large N.E. fault mentioned above. These workings extend as far as Nether Wellwood, about half-way between Lugar and Muirkirk. At the present time only three pits are working, and very little stone is being raised. The seam varied in thickness from 8 or 10 to as much as 36 or 40 in. Sections from some of the workings are given below :—

	Common No. 15.		Carbellio.		Berryhill.	
	Ft.	In.	Ft.	In.	Ft.	In.
Blacks	.	1 6½	1	10	1	1
BLACKBAND	.	1 11½	1	9	1	4

The general distribution of the Lugar Blackband and the more important faults are shown in Fig. 6, where an attempt is also made

to indicate the condition of the seam in different parts of the area.

An examination of the map shows that the ironstone is practically exhausted in the district.

Between the Glenlogan workings and the outcrop to the east the seam was spoilt by the intrusion of the Lugar sill which in some places overlies, in others underlies, the blackband ironstone. By the action of hot igneous matter on a blackband ironstone one might expect the formation of metallic iron, or at any rate magnetite, and unless the sill had actually absorbed the ironstone, or had caught it up in fragments too small to work, it seems difficult to understand why the iron should not still be present in some form or another.

In the area near Roadinghead the seam became unworkable, owing to the badly-faulted nature of the ground. To the south of Cumnock again the workings were abandoned as the seam had diminished in thickness to 7 or 8 in.

A small proved area of Lugar Blackband still exists to the north-west of the present workings near Berryhill, and to the south of the same workings the seam probably occurs in workable thickness as far as the line of the large north-east fault. West of Auchinleck the ironstone will doubtless be found under the Mauchline basin, but has so far not been proved. Unless of exceptionally good quality and thickness, however, it would not pay to work at the depth—in many cases over 300 fms.—at which it must occur here. Still farther west, in the centre of the basin, the Lugar Blackband, if present, must lie very deep indeed; at the Barony Pit, for example, the depth to the ironstone is estimated at 400 fms.

West of the Mauchline district again the seam is exposed near Coylton and Martnaham Loch, where it was at one time worked on a small scale. Small workings were also carried on at Raith Hill and Holebogs, near Sundrum, by the Dalmellington Iron Company, but these were abandoned owing to the silicious quality of the stone, and the highly-faulted nature of the ground.

In the area lying south-west of Cumnock, very little is known of the quality of the blackband, but the evidence available (such as the exposure in Carsgilloch Runner) is not promising, although the possibility exists that small workable fields may yet be proved between Polquhairn and Auchlin Rig.

A few small patches of unwrought stone still remain to the south of the large north-east fault near Wellwood, between Lugar and Muirkirk. The beds are much disturbed, however, and the field is probably of little value.

An analysis of the calcined Lugar Blackband shows :—

	Per cent.
Iron	49·0
Silica	13·0
Manganese oxide	1·6
Sulphur	0·18
Phosphorus	0·6
Lime	7·1

For an approximate estimate of reserves at this horizon, see table on p. 48.

Craigmark Ironstone Position.—The Craigmark Ironstone of

Dalmellington (p. 44) is either absent or represented by a few inches of parrotty blaes.

ESTIMATED RESERVES OF IRONSTONE IN AYRSHIRE

Name of Seam.	For Description see	Area in Acres.	Reserves in Tons.		
			Proved.	Probable.	Possible.
(1) COAL MEASURES.					
Craigmark Blackband . . .	p. 44	700	2,450,000	...	...
Planx Blackband . . .	p. 39	640	...	1,000,000	...
Moneur Musselband . . .	pp. 37-8	360	...	...	1,440,000
Kilwinning Main Coal Iron-stone . . .	p. 39	1,280	...	...	5,750,000
Dalmellington Blackband } . . .	pp. 42-3	2,620	1,500,000	...	6,200,000
Lugar Blackband } . . .	pp. 46-7	5,120	3,200,000	...	20,000,000
(2) LIMESTONE COAL GROUP.					
Logan's Claybands . . .	pp. 28, 32	7,680	...	...	30,750,000
Garibaldi Claybands . . .	pp. 9-31	2,560	...	...	5,000,000
Dalry Clayband . . .	pp. 18, 19 and 24	11,840	...	54,000,000	...
Total . . .		7,150,000	55,000,000	69,140,000	

IRONSTONES IN THE MILLSTONE GRIT VOLCANIC ROCKS.

In the northern part of the Ayrshire Coalfield the Millstone Grit Series consists mainly of fireclays and lava flows, with subordinate beds of ashy sediments, and a limited amount of sandstone and blaes; a few fossiliferous limy bands occasionally occur near the base of the series.

The general section of Millstone Grit Series is as follows:—

COAL MEASURES (a thin coal is often the basal bed).

MILL. STONE GRIT.	Upper Fireclay.—Hard fireclay	4-10 ft.
		Lava (rotten) often ferruginous . . . 3-6 ft.
		Red sedimentary layer . . . a few in.-2 ft.
	Lava flows with occasional inter-bedded sediments . . .	6-20 fms.
	Lower Fireclay.—Sediments (mainly fireclay) . . .	to 30 ft.
	Sediments (mainly sandstone) . . .	to 20 ft.

CARBONIFEROUS LIMESTONE SERIES.

There is a considerable variation in the thickness of the series in different localities. A bore at Smithstone, north-west of Kilwinning, gave a total thickness of 34 fms. Another at Redstone, north-east of the same place, gave a thickness of about 22 fms. The natural sections on the Lugton Water, near Montgreenan, show a total thickness of only 7 or 8 fms. The lavas are always present, and above and below them there are always beds of fireclay. The lavas occur as definite beds or flows, with thicknesses varying from 3 ft. to 20 or 30 ft. and in number from two or three to about twelve. In some places the lower flows are fresh and in good preservation, but more often

they are all much decomposed, probably by exposure to the atmosphere before they were covered over by the succeeding beds. In this way in many cases there has been a local enrichment in iron, producing beds that are possible sources of iron ore. Analysis of the iron-bearing beds generally show that they contain a high percentage of alumina and little lime and magnesia. Their association with seams of bauxitic fireclay also suggests that their origin bears some resemblance to that of the Antrim iron ores.

The beds which show a concentration of iron are not confined to any definite horizon, and may occur anywhere from top to bottom of the series. Neither is the enrichment confined to any particular kind of bed, as both sediments and lava flows are affected. In some places the fireclays are full of specks of carbonate of iron. The enrichment of the lava flows takes place in two distinct ways:—(1) the whole of the bed may be affected in the same manner from top to bottom, or (2) the enriched portions may consist of doggers or nodules scattered through a more argillaceous mass of rotten lava. In both cases the joint faces are often covered by thin layers of limonite.

Information regarding the iron ore beds has been obtained mainly from exposures in stream sections and in cliffs. Few bores have been carried through the Millstone Grit Series, as bores for coal were usually stopped on reaching the igneous rocks.

The Millstone Grit outcrops in the district may best be divided into three areas.

AREA 1 (NORTH OF THE DUSK WATER FAULT).

A series of small outliers occur on the north side of the Dusk Water boundary fault between Corsinkell and Giffen House. Except at the south-west end (the Glen Burn) this outcrop has not been recently examined for ironstones. Near Smithstone and Lochwood small patches of the upper lava flows occur under the small outliers of Coal Measure rocks. In the early days of the Glengarnock Ironworks a quantity of the material from near Smithstone was tried in one of the furnaces. The experiment was by no means a success, and the resulting iron was so hard and siliceous that it had to be blasted out of the bottom of the furnace. Farther north near Monkcastle only the lower lavas of the suite occur; these are usually still fairly fresh igneous rocks, and no special enrichment has taken place. The same may be said of the rocks in the outcrop which stretches for three miles in a north-easterly direction from Blair House.

The only exposure that need be considered in detail is the Glenburn one.

Glenburn.

Ordnance and Geological Sheets 1-in. 22; 6-in. Ayr, 16 N.W.

This exposure is situated $\frac{1}{2}$ mile N.W. of Corsinkell and $1\frac{1}{4}$ miles N. of Stevenston.

In this locality a good section through the lower members of the Millstone Grit Lava Series is exposed. The total thickness cannot be measured as there is a certain amount of faulting and the upper portion is cut out. The lava flows dip at an angle of about 30° to the S.W., and numerous interbedded fireclays, dirty coals and sandy

beds are to be seen. The lowest lavas are very ferruginous, but the outcrop can be followed only for a few yards. The section here is as follows:—

A Hard red bed	1-1½ ft.
B Soft white clayey bed with numerous specks of carbonate of iron and strings and doggers of material (C) very similar to A (up to 9 in. thick)	6-7 ft.

Analyses of beds A, B and C (by Messrs. D. Colville & Sons, Glengarnock) gave the following results:—

	(A) Per cent.	(B) Per cent.	(C) Per cent.
Iron	28·20	17·16	33·10
Silica	10·60	18·70	10·50
Alumina	14·70	27·70	9·00
Phosphorus	·022	·189	·044
Sulphur	·275	·110	·046
Manganese oxide	·28	·13	1·20
Lime	2·48	2·03	1·48
Magnesia	3·42	2·45	2·77
Loss on ignition	26·80	23·40	27·80

AREA 2 (MAIN OUTCROP FROM SALTCOATS TO KILMARNOCK).

This area comprises the large and almost continuous outcrop extending from Saltcoats shore eastwards through Kilmaurs to Rowallan Castle, near which place the outcrop branches, one branch going towards Hareshaw Lodge, and the other E.S.E. to Raws. Several analyses have been made of material from various localities (see below) along this outcrop, and the results, though not very promising, seem to indicate the possibility that areas of workable ore may occur as narrow strips along it.

(1) Brackleheugh (*Breakplough*).

One-in. Sheet 22 ; 6-in. Ayr, 16 N.W.

A good section is exposed on the sides of the Brackleheugh Burn, $\frac{1}{4}$ mile N. of Stevenston, near Kerelaw Mains. It shows:—

	Ft.	In.
Hard white fireclay	8	0
Rotten lava with <i>ferruginous doggers</i>	2	6
Thin fireclay (blue)	1	0
Rotten lava (<i>now ironstone</i>)	4	0
Thin fireclay, yellowish	0	6
Ironstone band (variable)	3 in. to	0 6
Rotten lava	10	0

The 4-ft. rotten lava near the middle of the sequence is good iron-stone at this locality; the outcrop can be traced about 6 yds., and the material is uniform for the whole distance. The following analysis of a sample from top to bottom of this bed has been supplied by Messrs. D. Colville & Sons, Glengarnock.

	Per cent.
Iron	42·43
Insoluble	24·80
Silica	15·00
Alumina	9·80
Phosphorus	·061

	Per cent.
Sulphur	·020
Manganese oxide	·465
Lime	·70
Magnesia	·28
Combined water, etc.	11·50
Moisture	1·16

The section exposed here is cut by a fault running parallel with the burn, and as there are buildings on both sides no work could be done at the outcrop. A search for this bed has recently been made by boring and trial pits in the ground to the south-west on the farm of Mayfield. One of these bores contained no ironstone at this horizon. Another bore nearer the outcrop showed at $27\frac{1}{2}$ fms. 24 ft. of material, averaging 20 per cent. of iron and 44 per cent. of insoluble material; 3 ft. 7 in. of this thickness contained 25 per cent. of iron and 34 per cent. of insoluble matter.

The trial pit west of Mayfield House contained 3 ft. of material which consisted mainly of carbonate of iron in a highly aluminous groundmass. This material was very soft, and could readily be crushed, in which condition the heavier iron carbonate can easily be separated from the clay by ordinary panning. A sample treated in this way and then further separated by magnetic means gave a highly ferruginous concentrate of about 50 per cent. of the original sample.

	Iron.	Insoluble.	
Calcined heavy washings. { (a) Very magnetic	49·45	7·80	About 50 per cent. of the whole.
(b) Less magnetic	31·18	18·00	
(c) Non-magnetic	3·24	64·00	
Partially calcined light washings. {	28·35	30·00	About 30 per cent. of the whole.

The other 20 per cent. was washed away as light clayey matter.

By finer crushing and more careful panning no doubt a good deal of the iron in the light washing could be saved, and carried over to the heavy portion.

(2) Lugton Water.

One-in. Sheet 22 ; 6-in. Ayr, 12 S.W.

The outcrop of the Millstone Grit Lava Series is well seen in the Lugton Water between Sevenacres Mains and Montgreenan. The total thickness is only about 30 ft., and the beds can be traced on both sides of the stream for 100 yds. The section exposed on the north bank, near Sevenacre Mains, is as follows:—

	Ft. In.
Section No. 1. { 1. Thin coal	6 0
2. Hardened fireclay	6 0
3. Very rotten lava (ferruginous)	4 to 5 0
4. Red ferruginous sediment	1½ ft. to 2 3
5. Lenticular patch of pyritous shale	up to 4 0
6. Rotten lava with ferruginous doggers	6 0

The occurrence of ironstone (Bed No. 3) was noted at this locality by John Smith* in 1886, and soon afterwards an attempt was made

* J. Smith, "On a Bed of Ironstone in Trap Tuff," *Trans. Geol. Soc., Glasgow*, 1893, vol. x, p. 133.

to work it. Operations soon ceased however, owing to the poor quality of the stone.

On the south side of the Lugton Water, near Sevenacres Mains, there is another exposure of beds numbered 2, 3 and 4. The section is as follows:—

Section No. 2.		Ft.	In.
2.	Hardened fireclay	2	6
	Irony rib	0	4
	Hardened fireclay	2	6
3.	Very rotten lava (ferruginous)	3	3
4.	Red ferruginous sediment	1	2

The very rotten lava No. 3 is very similar in both exposures, and consists of a reddish or a greenish matrix through which numerous specks of iron carbonate are scattered. For analyses see below.

The upper members of the same group are again well seen on the south side of the Lugton Water near Caven Mill. This section exposed on the top side of the road in Montgreenan Policies at an old road metal quarry, shows:—

Section No. 3.		Ft.	In.
1.	Hardened fireclay with numerous ferruginous patches	6	0
	Gap	about	7 0
2.	Rotten lava, in places full of small ironstone nodules	6	0
3.	Ironstone rib (haematite)	0	2
4.	Rotten lava	1	6
5.	Red ferruginous sediment	1	6
6.	Rotten lava	10	0

Farther north in an old quarry on the roadside near the top of the hill, the section is as follows:—

Section No. 4.		Ft.	In.
2.	Rotten lava, in places full of small ferruginous nodules	8	0
5.	Red ferruginous layer, the top 9 in. nodular	2	2
6.	Rotten lava	4	0

For analyses of Nos. 2 and 5 see below.

Analyses of Samples from the Lugton Water.

Section No. 2.*

	Bed No. 3. Top 18 in.		Bed No. 3. Bottom 21 in.		Bed No. 4
	Raw.	Calcined.	Raw.	Calcined.	Raw.
Iron	24·32	29·50	28·54	34·49	7·80
Silica	15·54	19·26	16·54	20·80	35·72
Alumina	29·48	36·55	22·05	27·73	..
Lime	0·80	0·95	0·95	1·20	..
Magnesia	1·64	2·03	1·50	1·90	..
Manganese oxide	0·43	0·53	0·46	0·57	..
Titanium oxide	0·50	0·62	0·40	0·52	..
Phosphorus	0·19	0·23	0·23	0·29	..
Sulphur	0·06	0·06	0·03	0·04	..
Loss on calcining	19·35	..	20·50	..	..
Sp. Gr.	3·10	..	3·19	..	..

* Analyses communicated by Messrs. D. Colville & Sons, Glengarnock Iron and Steel Works.

Section No. 1.

Analysis of Material taken from a Trial Mine at Section 1.*

	Per cent.
Peroxide of iron	26·31
Carbonate of iron	·32
Carbonate of magnesia	·23
Sulphuric acid	·18
Alumina with traces of manganese and phosphoric acid	21·53
Silica	41·20
Combined water	8·45
Moisture	1·78
	<hr/>
	100·00
Iron	18·42

Section 4.

	Percentage of iron in calcined material.
Rotten lava (Bed No 2)	18·17
Red ferruginous layer (Bed No. 5)	23·46

(3) Fenwick Water.

One-in. Sheet 22; 6-in. Ayr, 18 N.W.

The Millstone Grit Lava Series is well exposed in the sections on the Fenwick Water, near Assloss House, and also in the Crawfurdland Burn. The section is very similar to that seen in the Lugton Water, and the hardened fireclay contains numerous large doggers of red iron ore.

Several analyses have been made of material from this district.

Decomposed top lava flow of the Millstone Grit from bed of Fenwick Water, about one-sixth mile N.N.W. of Assloss House. Analysed Geological Survey Lab. (No. 435).

Iron 34·86 per cent.

Analysis by E. G. Tosh, for Mr. H. Dunn.

Samples said to be taken from the top of the Millstone Grit Lava Series in the Fenwick Water.

	Green Specimen. Per cent.	Brown Specimen. Per cent.
Protoxide of iron	34·84	28·72
Peroxide of iron	2·94	5·11
Protoxide of manganese	0·22	1·01
Silica	17·43	19·60
Alumina	19·22	16·82
Lime	1·43	2·
Magnesia	1·45	0·69
Water	9·20	11·29
Carbonic acid	13·23	14·68
Phosphoric acid	0·04	0·08
Sulphuric acid	trace	trace
	<hr/>	<hr/>
	100·	100·
Iron (Fe)	29·16	25·92

* By Dr. Wm. Wallace, for Messrs. Wm. Baird & Co.

AREA 3 (SPITTALHILL TO BOGHEAD).

The third area over which rocks of Millstone Grit age are found in N.W. Ayrshire extends from Spittalhill to Boghead, near the southern border of 1-in. Geological Survey Sheet 22. Little information as to the ferruginous character of the lavas along this outcrop is as yet available.

Arran.

Igneous rocks, closely resembling those just dealt with, are found at the same horizon in the Island of Arran. They are well seen in the small burns about $\frac{3}{4}$ mile north-east of Brodick Castle, and about $\frac{1}{2}$ mile from the sea. So far as the outcrops show there is no indication that they contain available resources of iron-ore.

LANARKSHIRE.

Bankend, Coalburn and Douglas Outlier.

The area of Carboniferous rocks lying in the southern part of 1-in. Sheet 23, and extending as a narrow strip up the Douglas Water into the Glespin field in Sheet 15, forms a distinct geological unit. It is separated from the Central Coalfield by the broad belt of Old Red Sandstone strata which runs from Lesmahagow to Lanark, while to the south-west rocks of the same age isolate it from the Muirkirk-Glenbuck basin. The stratigraphical sequence in this outlier closely resembles that at Muirkirk, and the names given to the principal coal and limestone horizons are for the most part common to the two fields. Hence a note upon the ironstones of the Coalburn-Douglas area follows most naturally upon the account of South Ayrshire. All the subdivisions of the Carboniferous formation, from the Upper Barren Red Measures to the Calciferous Sandstone Series, are present here, but the only one that need be considered in detail is the Limestone Coal Group.

Maps:—One-in. Geological Sheet 23; 6-in. Sheets Lanark, 31 S.E.; 32 S.W., S.E.; 37 N.E., S.E.; 38 N.W., S.W., N.E.; 41 N.E.; 42 N.W.

LIMESTONE COAL GROUP.

The general sequence for this group in the Coalburn field is shown in the following table:—

		Thickness.
		Fms. Ft. In.
SEVEN-FOOT (OR INDEX) LIMESTONE	.	1 1 0
Strata	.	4 0 0
COAL (GAS C. OF BANKEND), variable and often thin; locally	.	0 2 3
Strata	variable, $2\frac{1}{2}$ to	7 0 0
SMITHY COAL	.	0 2 8
Strata	variable, about	0 2 0
DROSS COAL	.	0 2 10
Strata	2 ft. 2 in. to	0 2 0
ELL COAL	.	1 or 2 0 0
Strata	1 ft. 10 in. to	0 2 8
COAL	.	2 to 4 0 0
Strata	.	0 1 2
BLACKBAND IRONSTONE	.	2 in. to 0 1 0
Strata	variable, 8 ft. to	2 0 0

		Thickness.
		Fms. Ft. In.
NINE-FOOT OR SPLINT COAL	variable, say	1 0 0
Strata	about	5 0 0
Blaes and clayband ribs, with <i>Lingula</i>	about	3 0 0
Strata	about	1 0 0
COAL	generally thin, sometimes absent, say	0 1 3
Strata	4 or	5 0 0
SIX-FOOT COAL	say	0 4 6
Strata	8 to	10 0 0
Shelly marine band		1 0 0
MACDONALD OR STINKING COAL	1 ft. to	0 4 0
Strata	about	8 0 0
[TOP MACDONALD LIMESTONE (=TOP HOSIE)]		60 1 4

The names given in this table are those used at Bankend, Dalquhandy, Auchlochan and Bellfield. The sequence compares closely with that at Muirkirk and Glenbuck (see table on p. 36). The following points are of general stratigraphical interest:—

(1) The Nine-foot Coal corresponds to the seam of the same name at Muirkirk. It contains one or two ribs of cannel, and is divided into leaves by partings of variable thickness. It may show, for example, such a section as:—

	Ft. In.
COAL	2 6
Strata	6 0
COAL	4 3

(2) The blaes and clayband ribs in which *Lingula* is found are the equivalent of the horizon at which the High-band and Low-band occur at Muirkirk (see p. 36). They represent the "Black Metals" group of the Central Coalfield (see p. 80).

(3) The thin coal found a few feet under these claybands represents the Thirty-inch coal of Glenbuck.

(4) The Six-foot Coal is the same as the Catchyburn of the Muirkirk field. It contains a little cannel, and is very probably the equivalent of the Lesmahagow Main Gas Coal (see p. 104).

(5) The "shelly marine band" overlying the Macdonald Coal represents the Wee Lingula Limestone or Slingstone of the Carlisle field or the Johnstone Shell-bed of the West of Scotland (see p. 70).

(6) The Macdonald Ironstone of the Muirkirk section (p. 44) is represented in this field by a bed of blaes containing clayband balls. It lies upon approximately the same horizon as the Dalry or Johnstone Clayband (cf. table on p. 36 with the sections on p. 26).

(7) The total thickness of the Limestone Coal Group in the Coalburn field is about 55 to 60 fms. It is less than this in the centre of the outlier, but on the eastern side again, at Ponfeigh and Rigside, increases to over twice this thickness, and contains a greater number of workable coals—no less than ten.* The nomenclature adopted here is purely local; the Dross Coal of the Coalburn section is probably represented by the Big Drum Coal, the Ell by the Skaterigg, while the leaves of the Nine-ft. seam may be the equivalent of the Kirkroad and Stoney Coals; the Thirty-inch of Muirkirk is represented by the Back Seam, the Six-foot by the Robb and

* For section see Weir, "The Douglas Coalfield," *Trans. Instit. Min. Eng.*, vol. xvi., 1899, p. 440.

Fallowhill Coals, while the Macdonald Coal is known as the Wood seam.

The group as a whole is very poor in workable ironstones. The first that calls for mention is the blackband lying a fathom or two above the Nine-foot Coal. It was discovered in the Bankend field about 1847. Averaging some 7 in. in thickness, and associated with a thin craw coal, it was wrought for a number of years both at Bankend and at Auchlochan, supplying a very considerable amount of ore to the Scottish iron industry in the days when blackband-mining was at its height. It is stated to have been of excellent quality, but, as in the case of so many of our ironstones, the increasing costs of working and the competition of foreign ore led to its abandonment. The seam is still intact over considerable areas in the Coalburn district, where it varies from 2 to 12 in., but is not likely to be reopened. Apart from the economic difficulties involved, there is the additional one that the workings of the Nine-foot Coal lie only a short way below the Blackband seam. In the Ponfeigh area again a thin blackband (about 8 in.), overlain by a few inches of irony parrot, is found at the same horizon not far above the Kirkroad Coal, and has been wrought to some extent.

The clayband ribs found midway between the Nine-foot and Six-foot Coals (see note 2, p. 55) were formerly worked at Bankend and Auchlochan in the days before the Blackband seam was known of. These ribs average only 2 to 6 in. each, but locally as much as 11 in. is recorded; they are not likely to attract attention in the future, but merit mention because they represent the ironstones known as Logan's Bands in N. Ayrshire, while at Muirkirk on the same horizon occur the High-band and Mid-band ironstones. The Low-band and Macdonald ironstones of the Muirkirk section (see p. 44) are poorly represented in this area. Clayband ribs, a few inches in thickness, or clayband nodules, occur in the position of the former, associated with the blaes overlying the shell-bed above the Macdonald Coal. It ought to be added that very little evidence is available regarding these seams at Glespin, and it is possible they are better developed there.

In addition to the above some of the workable coals are locally associated with clayband ribs. Thus the Big Drum of Ponfeigh and the Six-foot of Auchlochan are sometimes accompanied by ironstones which are worked along with the coal. The first-named seam was found, near its outcrop, to have as much as 14 in. of ironstone immediately below the coal, but this gradually died away to the dip.* Clayband ribs occur also in the roof of the Kirkroad Coal, and a thin blackband is locally found a foot or two below the Robb seam.

COAL MEASURES.

Strata of Coal Measure age occur along the valley of the Douglas Water from Douglas to Glespin. The collieries at present working here are Douglas Castle, Glebe and Glespin. No ironstones of economic value are known to occur in the Coal Measures of this area. The Lugar Blackband is not developed here so far as is at present known. One or two thin "musselbands" are recorded, but we have no information as to the iron-contents of these.

* See Weir, *op. cit.*, p. 441.

CHAPTER III.

BEDDED ORES OF CARBONIFEROUS AGE (*continued*).

CENTRAL COALFIELD.

THE wide area of Carboniferous rocks to be dealt with in this chapter includes not only the whole of the great Lanarkshire coal basin but also those portions of the adjoining counties which are structurally part of it. Within its limits the Central Coalfield comprises the whole of 1-in. Sheet 31, together with parts of Sheets 22, 23, 24, 30, 32 and 39. A series of memoirs on the detailed economic geology of this coalfield is being issued by the Geological Survey in nine separate parts, of which three have already been published, namely :—

Area V. (Glasgow East, Airdrie, Coatbridge, etc.), 1916.
Area VIII. (East Kilbride and Quarter), 1917.

Area II. (Denny, Falkirk, Slamannan, etc.), 1917.

The boundaries of these areas and the 1-in. and 6-in. Ordnance and Geological Survey Sheets concerned can readily be found by reference to the index-map issued with each volume.

CALCIFEROUS SANDSTONE SERIES.

At a few localities ironstones in the upper part of this series have been worked on a small scale at their outcrops. They are of very little value nowadays, and are briefly dealt with.

Cot Castle Blackband.—In the River Avon at Cot Castle, about $2\frac{1}{2}$ miles north-east of Strathaven (Lanark, 6-in. Sheet 24 S.W.), there is exposed an excellent section of strata at the top of the Calciferous Sandstone Series. The Cot Castle Blackband of this district lies 22 fms. under the Main Limestone. It was worked about 1860, along the river front between Cot Castle and Bankhead, for about 400 ft. in from the face of the cliff, but can still be seen at two points.—*

(1) On the east bank just above the mouth of the Lounsdale Burn.

(2) On the west bank 100 yds. south of Bankhead Farm.

It is about 12 in. thick; in the "Explanation of Sheet 23" (*Memoirs of Geological Survey*, 1873) the section recorded is :—

	Ft.	In.
Maggie † shale	0	4
BLACKBAND, poor	0	8
Maggie shale, sulphury	0	4
COAL, kind of parrot	0	4

* R. G. Carruthers, "Carboniferous Sediments around Strathaven," *Trans. Geol. Soc. Glasgow*, vol. xv., part II, 1914, p. 158.

† See glossary on p. vi.

This blackband immediately underlies a richly fossiliferous impure limestone or limy blaes, known from its being first recorded in the River Calder, near Basket Farm (2 miles north-east of East Kilbride), as the Basket Shell-bed.* This marine horizon serves to fix the position of the blackband in neighbouring bores, and a study of these shows that it has attracted no attention. One bore records 2 ft. of hard blaes in the position of the ironstone. It may be mentioned here that the Cot Castle Blackband is represented in the Calderwood Glen Section by a 7 to 10-in. coal.†

At one or two other localities a blackband in the upper part of the Calciferous Sandstone Series has been recorded. These occurrences may be tabulated as follows:—

Blackburn (Linlithgow; 6-in. Sheet, 9 S.E.).—In one or two bores near Blackburn a thin blackband of about 9 in. is recorded as occurring some 27 fms. below the Main Limestone (here known as the Cobbinshaw-Hurlet Limestone).

Auchengray (Lanark; 6-in. Sheet, 20 N.E.).—The Geological Survey “Explanation of Sheet 23” (1873), p. 26, notes:—

“A seam of blackband ironstone was sunk to at Easterhouse, but it has not as yet been proved to exist in a workable condition in other parts of the district.”

Middleton Hall, Broxburn ‡ (Linlithgow; 6-in. Sheet, 6 S.W.).—There is at Middleton Hall a small basin containing beds which cannot be far below the Cobbinshaw or Main Limestone. This basin, which is truncated to the south by the great Middleton Hall Fault, contains a seam of blackband ironstone which lies approximately 25 fms. below the Cobbinshaw Limestone. The section of the seam (as proved in a bore) showed:—

		Ft.	In.
BLACKBAND IRONSTONE	.	0	1½
Coal and Blaes	.	0	1½
BLACKBAND IRONSTONE	.	1	1½
Fireclay	.	0	2

A trial pit proved its thickness to be 18½ in., but of its extent and quality nothing is known. It can occupy at most an area of, roughly, 27 acres, and in the centre of the basin is perhaps 18 or 20 fms. deep.

As these occurrences of blackband are purely local, it is not worth while entering on questions of correlation. The Blackburn and Middleton Hall ironstones are approximately on the same horizon and may, perhaps, represent the Cot Castle Blackband. On the other hand, where the Basket Shell-bed has been definitely recognised in their vicinity, as in borings around Cobbinshaw, the blackband position is occupied by coal and coaly blaes.

Cot Castle Claybands.—Along the cliff section in the River Avon, between Cot Castle and a point opposite Bankhead, one or two somewhat calcareous claybands were wrought about 1860. These have been mined all along their outercrop round the cliff and to a distance of some 200 ft. from the river (about 17 acres in all) and are no

* “Econ. Geol. Central Coalfield, Area VIII.,” *Mem. Geol. Surv.*, 1917, p. 10.

† *Ibid.*, pp. 5, 10 and 12.

‡ Really outside the limits of the Central Coalfield. See “Oil-shales of the Lothians,” *Mem. Geol. Surv.*, 1912, p. 52.

longer visible. They overlie the Basket Shell-bed, and are therefore only a few feet above the Cot Castle Blackband also worked in the same locality (see p. 57). There appear to have been two claybands varying from 2 to 9 in. in thickness. In bores on Crumhaugh, Udston, etc., they are recorded as ribs of 2 to 5 in. only.

Whitestone Claybands.—In the gorge of the River Calder, between Calderwood Castle and Crossbasket Bridge, some claybands were formerly wrought opencast by Messrs. Colin Dunlop & Co. As now seen in natural section on the east bank of the river, about 200 yds. west of Basket Farm, they show: *—

	Ft.	In.
Blaes with a few thin clayband ribs	7	0
CLAYBAND	0	4
Blaes	2	2
CLAYBAND	1 in. to 0	4
Blaes	2	4
CLAYBAND	1 in. to 0	4
Blaes	0	11
CLAYBAND	0 to 0	3
Blaes	0	6
BASKET SHELL-BED		

In an old account of the Blantyre Parish minerals † the Whitestone is described as "the richest seam" of the Crossbasket district. The Whitestone Claybands lie 10 or 11 fms. under the Main Limestone.

Balls and thin ribs of clayband are known elsewhere at this horizon, i.e. in the Cobbinshaw district, but are of no economic value.

Kilpothall Ironstones.—A distinguishing feature of the Calciferous Sandstone Series of the Braehead district is the occurrence, a little way below the Main Limestone, of a group of workable claybands. These are known as the Kilpothall or West Sidewood Ironstones. They were wrought towards the middle of the last century both opencast and by shallow pits between Kilpothall and the Wilson, town Road, near West Sidewood. The beds are nowhere exposed, and there is very little information to be gleaned regarding the quality, thickness or extent of the seams. Several bores on Crofthill and West Sidewood record ironstone ribs at what appears to be this horizon. These ribs vary in number from 8 to 14. They are generally 1 to 4 in. in thickness, but reach in some instances as much as 7, 8, or even 11 in. They die out rapidly westwards, and are apparently absent or poorly developed to the north and north-east.

LOWER LIMESTONE GROUP.

This group is characterised by the presence of six or seven beds of shelly marine limestone associated with thick beds of blaes. The limestones have been locally worked on a considerable scale for agricultural and industrial purposes. The blaes horizons contain lenticular ribs or nodules of clayband ironstone which in some districts have proved an important source of ore. The most valuable of these are the Househill Claybands of Hurlet and Nitshill which

* See "Econ. Geol. Central Coalfield, Area VIII.," Mem. Geol. Surv., 1917, p. 5.

† Written 1835, see "Statistical Account of Scotland," vol. vi., p. 317.

are still mined, and the Raesgill Ironstones of Carluke. The group is poor in coals; the only seams of economic value are the Hurlet Coal, the Wilsontown Smithy Coal and the Lillie's Shale-coal.

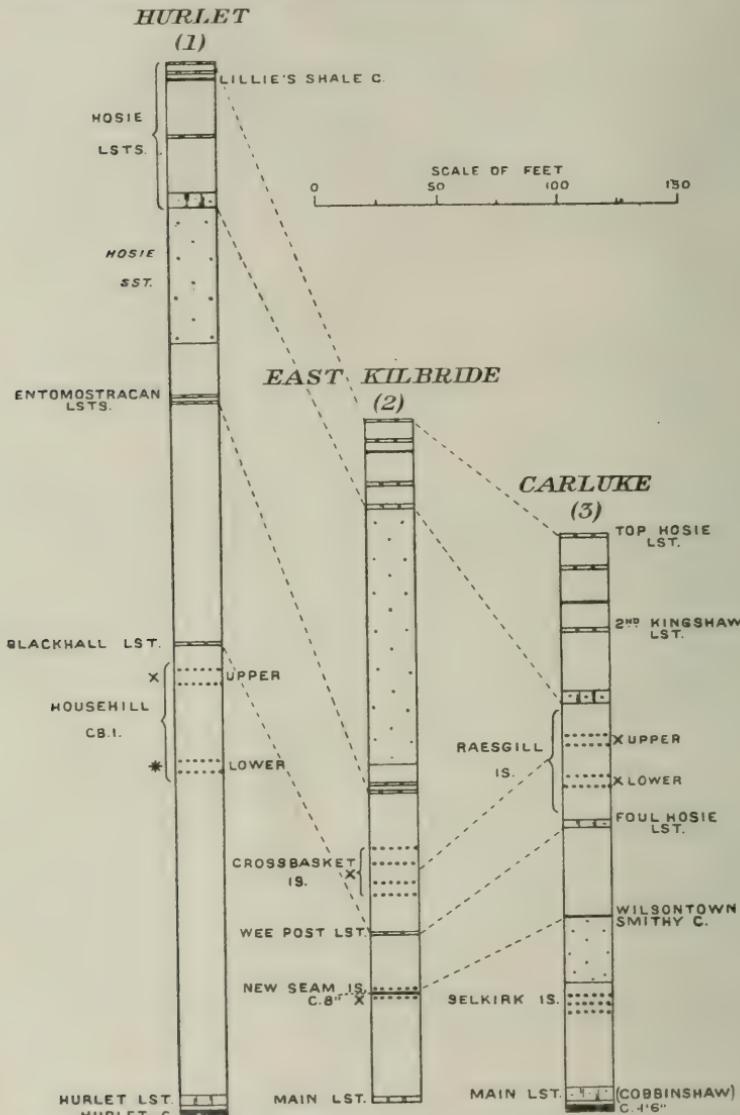


FIG. 7.—Comparative Vertical Sections of the Lower Limestone Group, Central Coalfield.

C. = Coal.

IS. = Ironstone.

CB.I. = Clayband Ironstone.

* Indicates seams at present worked.

LST. = Limestone.

SST. = Sandstone.

X Indicates seams formerly worked.

Comparative vertical sections showing the chief stratigraphical horizons in this group at Hurlet, at East Kilbride, and at Carluke, will be found in Fig. 7.

The ironstones shown in these sections are the following:—

Selkirk Ironstones.—In the Carluke district the blaes above the Main Limestone contain a number of thin ribs of clayband known as the Selkirk Ironstones. They are recorded at Craigenhill, Kilncadzow, Birniehall, etc., but are only a few inches thick, and are often described merely as "blaes and balls." They have not been worked so far, though where near the surface might yield a small supply of ore.

Househill Claybands.—These claybands take their name from the farm of Househill, which lies slightly over two-thirds of a mile N. 15° E. of Nitshill Station (Renfrew, 12 S.E.). They occur in the Lower Limestone Group between the Blackhall and Hurlet Limestones. The strata between these limestones consist of blaes in which lie a number of clayband ironstone ribs varying in thickness from 2 to 14 in., and somewhat calcareous in character. These ribs are thicker and more abundant in the upper part of the blaes, and two main ironstone horizons have been distinguished as the Upper and Lower Househill Claybands respectively. The former usually lies 8 to 12 ft. under the Blackhall Limestone, the latter some 4 to 6 fms. lower. The thickest of these claybands recorded in different shaft and bore sections are not necessarily, however, on exactly the same horizon.

(1) *South of the Clyde.*—The Househill Claybands are typically developed in the Hurlet-Nitshill district of Renfrewshire. They were formerly wrought from several pits lying along the Levern Water to the east of Hurlet, and are still raised at Messrs. Baird's Victoria Pits close to Nitshill Station. The sections recorded at the old Roughmussel and Turnberry No. 1 Pits (Renfrew, 12 S.E.) are as follows:—

	<i>Roughmussel Pit.</i>	<i>Turnberry No. 1 Pit.</i>
	BLACKHALL LIMESTONE	BLACKHALL LIMESTONE
	Blaes with ironstone	Blaes with iron-
	ribs 7 ft. 10 in.	stone ribs 10 ft. 10 in.
Upper	CLAYBAND 11 "	CLAYBAND 5½ "
	Blaes 4 ft. 10 "	Blaes 5 ft. 7 "
	CLAYBAND 14 "	CLAYBAND 14 "
	Blaes with ironstone	Blaes with iron-
	ribs 34 ft.	stone ribs 29 ft. 8 "
	CLAYBAND 11 "	CLAYBAND 9 "
Lower		Blaes 5 ft. 5½ "
		CLAYBAND 14 "

The clayband working in the existing Victoria Pits shows:—

	Ft. In.
Blaes with ironstone ribs	
CLAYBAND . . . . .	. . . . . 0 6
Blaes . . . . .	. . . . . 4 6
CLAYBAND . . . . .	. . . . . 0 3
Blaes . . . . .	. . . . . 2 6
CLAYBAND . . . . .	. . . . . 10 in. to 1 0

It lies here about 8 fms. below the Blackhall Limestone, and corresponds accordingly to the Lower Househill Clayband horizon. The shaft section records the following in the Upper Househill position:—

		Ft. In.
CLAYBAND	.	0 10
Blaes	.	1 11
CLAYBAND	.	0 9
Blaes	.	6 4
CLAYBAND	.	0 10 (about 15 ft. under Blackhall)

There is no doubt a considerable area east and south of the Victoria Pits where the Househill Claybands exist in workable thickness. The dip of the rocks, however, is to the south-east, and the Lower Clayband is 150 fms. deep in the existing shaft, so that in these directions the question of depth becomes of importance. Apart from this factor, difficulties of working due to faults and to the water lying in the old workings in the Hurlet Coal to the north-east of Nitshill have to be reckoned with.

North of Nitshill again, around Corkerhill, Crookston Castle and Hillington (Renfrew, 12 N.E.) the Househill Claybands occur in workable thickness. Bores near Crookston Castle and Hillington record the following sections:—

<i>Crookston Castle.</i>	<i>Hillington.</i>
BLACKHALL LIMESTONE	BLACKHALL LIMESTONE
Blaes with clayband ribs (up to 12 in.),	Blaes with clayband ribs, about 16 ft.
about 17 or 18 ft.	CLAYBAND, 4 to 6 in.
CLAYBAND, 4 to 7 in.	Blaes, about 2 ft.
Blaes, 2 ft. 4 in.	CLAYBAND, 12 in.
CLAYBAND, 10 to 14 in.	Blaes with clayband ribs about 27 ft.
Blaes with clayband ribs, 28 to 35 ft.	CLAYBAND, 2 to 7 in.
CLAYBAND, 5 or 6 in.	Blaes, about 3 ft.
Blaes, about 3 ft.	CLAYBAND, 6 to 8 in.
CLAYBAND, 4 to 12 in.	

These two ironstone horizons correspond approximately to the upper and lower horizons at Nitshill. The Househill ironstones worked at Messrs. Baird's Pollok Pit at Corkerhill lay $3\frac{1}{2}$ fms. below the Blackhall Limestone in the position of the higher horizon of the above sections. This pit stopped working in 1914, but is still being pumped and may be reopened. Both Johnstone and Househill Claybands were wrought here, but proved costly to work on account of faults.

East of Corkerhill there is little known about the development of the Househill Claybands. In the deep bore at Maxwell Park Station numerous clayband ribs are recorded in the blaes below the Blackhall Limestone. These vary from 2 to 8 in. in thickness. The following details will show the nature of the beds:—

	Ft. In.
BLACKHALL LIMESTONE (at 170 fms. 5 ft. 6 in.)	
Blaes and ironstone ribs	4 0
IRONSTONE	0 5
Blaes	2 0
IRONSTONE	0 8
Blaes	2 2
IRONSTONE	0 3
Blaes	0 6
IRONSTONE	0 4½
Blaes	2 5½
IRONSTONE	0 6
Blaes with ironstone ribs of 2 to 8 in.	57 0
IRONSTONE	0 3½
Blaes	0 4

	Ft.	In.
IRONSTONE	0	$4\frac{1}{2}$
Blaes	0	$10\frac{1}{2}$
IRON AND LIME (limy clayband)	0	9
Blaes	1	10
IRONSTONE	0	8

In the Johnstone, Paisley and Renfrew district the Househill Claybands are very poorly represented and, though proved in borings at many localities—*i.e.* Paisley Racecourse, Netherfield, Fulwood, Inchinnan, Hareshaw, Brownsfield, etc.—have never been got in workable thickness. At these places they are represented by thin limy ribs, with here and there an ironstone rib of a few inches. It may be noted that in some districts a thin coal occurs in the blaes between the Blackhall and Hurlet Limestone in the position of the Wilsontown Smithy Coal of the Wilsontown coalfield. This coal is generally thin, but reaches 14 in. in a boring at West Fulton (Renfrew, 7 S.E.). In the River Gryfe, near Bridge of Weir, it is 6 in. thick, and is underlain and overlain by blaes with ribs of ironstone representing the Claybands of Househill. One of these ironstones reached locally a thickness of 10 in., and was worked along with the coal to a slight extent in pits to the south-west about 1856.

(2) *North of the Clyde*.—Ironstones in the position of the Househill Claybands are known at Baljaffrey and Duntocher. In the old Prince Albert Pit, near the latter place (Dumbarton, 23 S.W.), the section of the strata at this horizon was:—

	Ft.	In.
LIMESTONE (BLACKHALL)		
Blaes	6	4
IRONSTONE	0	7
Blaes	1	8
IRONSTONE	0	3
Blaes	1	9
IRONSTONE	1	0
Blaes with ironstone ribs	20	10
IRONSTONE	0	6
Blaes	1	10
Ironstone (at 79 fms. 3 ft. 11 in.)	0	6

These claybands are still intact, and might possibly be worked from some of the abandoned shafts to the Hurlet Coal.

New Seam Ironstone and Coal of Crossbasket (Lanark: 6-in. Sheets 11 S.W.; 17 N.E.).—Reference has been made above to the occurrence of a coal in association with the Househill Claybands in the River Gryfe and elsewhere. A coal and ironstone seam on approximately the same horizon is found in the East Kilbride and High Blantyre district. In the River Calder, about 400 yds N. of Calderwood Castle, and on the west bank of the stream, we find the following exposure: *—

	Ft.	In.
Blaes with clayband lenticles, 1 to 6 in.	11	6
CLAYBAND	3 in. to	0
Coal	0	11
Dark fireclay	1	2
CLAYBAND	0	3

This clayband horizon lies about 7 fms. above the Main (or Hurlet) Limestone, and about 4 fms. below the Wee Post (or Blackhall) Lime-

* "Econ. Geol. Central Coalfield, Area VIII," Mem. Geol. Surv., 1917, p. 6.

stone. Just north of the exposure there are old opencast workings in this seam, and it was raised also in pits to the east of the river on the lands of Greenhall, Crossbasket and Newhouse. These pits, belonging to Messrs. Colin Dunlop & Co., ceased about 1886, and the section recorded on the plan of the workings is as follows:—

	Ft.	In.
Blaes roof		
IRONSTONE	0	$5\frac{1}{2}$
COAL	0	8
Dark blaes	1	3
IRONSTONE	0	$11\frac{1}{2}$

Some of the old pits to the Crossbasket ironstones were apparently deepened to work the "New Seam."

In the Strathaven and Wilsontown districts there is found at this horizon a workable coal $1\frac{1}{2}$ to 2 ft. thick. It appears to be well developed in the Wilsontown-Cobbinshaw field, and is called by the Geological Survey the Wilsontown Smithy Coal. At neither of these localities, however, are ironstones associated with it.

It may be added that along the north-western edge of the Central Coalfield, between Campsie and Denny, the position of the Househill Claybands is occupied by blaes containing ironstone balls, having very little economic value. In an old pit sunk to the Hurlet Coal on the top of the South Hill of Campsie, and north of Newlands, the following strata were passed through.

	Ft.	In.
BLACKHALL LIMESTONE	6 0
Blaes with 4 bands of IRONSTONE, 20 in. in all	6 0
Blaes	22 0
HURLET OR MAIN LIMESTONE	4 0
ALUM SHALE	2 0
COAL	3 8

The "New Statistical Account of Scotland" (1845)* states of these ironstones that they "are considered of good quality, and have been wrought to some extent." These beds can be seen in natural section in Baldow Glen on the northern slopes of the South Brae of Campsie, and in the Corrie Burn, on the south slopes of the Kilsyth Hills. At both localities thin representatives of the Household Claybands are present below the Blackhall Limestone. Some thin clayband seams proved in bores on Tomfyne on the north side of the large fault which limits the Banton field may, perhaps, represent this horizon. The ironstones proved here vary from 3 to 9 in.

Raesgill Ironstones (Carluke and district).—These ironstones consist of a number of lenticular ribs or nodular layers of clayband occurring in the blaes above the Foul Hosie Limestone.

They are best developed in the Carluke basin, around the margins of which they have been extensively wrought. A good section was formerly to be seen near the mouth of Rae's Gill, a small stream joining Jock's Gill, about $1\frac{1}{2}$ miles W. by S. of Carluke (Lanark, 18 S.E.). The section, now obscured by the old opencast workings in the ironstones, has been recorded both by Craig† and Rankine.‡

* Vol. viii., p. 241.

† "On the Carboniferous Formation of Lower Ward of Lanarkshire," *Trans. Highland and Agric. Soc.*, Second Series, vol. vi., 1839, p. 399.

‡ "Sketch of Geology of Carluke Parish," *Trans. Highland and Agric. Soc.* Second Series, vol. viii., 1843, pp. 88 and 92.

According to the latter some 12 ribs of clayband varying in thickness from 3 to 10 in., and amounting in all to between 6 and 7 ft., of iron-stone, were scattered at intervals of 1 to 5 ft. through 10 fms. of blaes. At a later date the ironstones were raised from pits at Hallraig (Lanark, 19 S.W.), where the workings extended over a considerable area north and south of Jock's Gill. Some of these deeper workings are dated as early as 1852, while the No. 1 Hallraig Pit of the Coltness Iron Company was not abandoned until 1900. The seams raised at this pit were:—

		Fms. Ft. In.
	FIRECLAY, 3 ft.	at 31 4 6
	WEE LIMESTONE 2½ ft. (=2nd Kingshaw)	at 33 0 3
RAESGILL IRONSTONES.	TOP OR 5-FT. WORKING	at 41 1 3
	MID WORKING	at 43 1 2
	LOWER WORKING	at 44 2 2

The sections of the three ironstone workings were:—

Top or 5-ft. Working.			Mid and Lower Workings.	
	Ft.	In.	Ft.	In.
Blaes roof			Blaes roof	
IRONSTONE	0	2½	IRONSTONE BALL	0 3
IRONY FAKE	0	1½	Blaes	3 0
IRONSTONE	0	2	IRONSTONE	8 in. to 0 10
Blaes	1	11½	Blaes	3 2
IRONSTONE	0	2½	IRONSTONE BALL	0 2
Blaes	2	3	Blaes	3 0
IRONSTONE	0	6	IRONSTONE	6 in. to 0 8
Blaes pavement			Blaes pavement	

The 5-ft. ironstone horizon was worked on a considerable scale down to the year 1900. Of the lower ironstone a small area was worked about the years 1874-7, while the Mid Seam was opened out in 1875, but apparently little worked. The Mid and Lower workings together constituted the 7-ft. working.

At Shieldhall again, a little east of Hallraig, and rather less than half a mile S. of Carlisle Station, the Raesgill Ironstones were worked by Messrs. Merry & Cuninghame. This pit was abandoned in 1875. The seams wrought were:—

	Fms. Ft. In.
LIMESTONE (=2nd Kingshaw), 2 ft. 3 in.	at 64 0 0
UPPER CLAYBAND	at 72 0 0
(LOWER CLAYBAND	at 74 0 0)

Of the Lower Clayband no record is available. The Upper Clayband, corresponding to the 5-ft. working of Hallraig, showed

	Ft. In.
Blaes roof	
IRONSTONE	2 in. to 0 2½
Blaes	0 1
IRONSTONE	1½ in. to 0 2
Blaes	1 0
BALLY BAND	1½ in. to 0 2
Blaes	2 ft. 3 in. to 3 0
IRONSTONE	4 in. to 0 5
Blaes pavement	

At the old Mayfield and Wilton pits again, to the S.E. of Carluke, the 5-ft. seam was worked over considerable areas. The sections here were much the same as the above, showing from 7 to 10 in. of clayband in all. Of still older date are the shallower pits to the Raesgill Ironstones south-east of Mayfield and Wilton, and the open-cast workings along Fiddler's Gill.

A large fault running N.W.-S.E. between Yieldshields and the Carluke Road shifts the outcrop of the ironstones to the north-west. They were formerly wrought opencast and from pits along the western margin of Kingshaw Moss, N.E. of Carluke. The most recent workings here were those of the Shotts Iron Co. in 1889 from No. 8 Pit, where the 5-ft. working was $25\frac{1}{2}$ fms., and the 3-ft. working $28\frac{1}{2}$ fms. deep. Most of the workings are much older. The sections were as follows:—

					Ft.	In.
Roof	Blaes					
	Foul band ironstone	.	.	.	0	4
5 ft.	Blaes, brushing	.	.	.	2	0
	IRONSTONE	.	.	.	0	3
working	Blaes	.	.	.	3	0
	IRONSTONE	.	.	.	0	5
	Blaes	.	.	.	18	0
3 ft.	Blaes and IRONSTONE BALLS	.	.	.	3	0
	IRONSTONE	.	.	.	0	7
working	Blaes	.	.	.	4	0

In the deeper parts of the Carluke basin the ironstones are still intact, but the sections already given make it clear that 7 to 12 in. of ironstone is all that can be expected in a working of 4 to 7 ft.

There are minor basins at Kilncadjow to the south-east of Carluke, and in these the Raesgills are found comparatively near the surface. Only in the largest one, however—at Bishopbent—is there any considerable area left unexploited (Lanark, 25 N.E.). Perhaps 130 acres of both the 5-ft. and the 3-ft. Ironstones exists here, the former with 12, the latter with 9 in. of clayband.

Braidwood.—At Braidwood the Raesgill Ironstones were wrought from a number of pits, long since abandoned, on both sides of the Carluke Road, and a little to the west again at Oldhill (Lanark, 25 N.W.). Very little is known of these. The opencast workings at Oldhill on the lands of Waygateshaw terminated against a 12-fm. downthrow on the north side of which a 40-fm. shaft was sunk to reach the ironstones. This shaft, worked by Messrs. Wm. Dixon & Co., showed 12 ribs of clayband, $2\frac{1}{2}$ to 6 in. thick, in 5 fms. of blaes. Here again not much of the ironstone remains untouched near the surface.

Braehead.—In the Braehead district, south of the great Wilson-town fault, the Raesgill Ironstones are again found near the surface, and seem to have attracted some attention about the middle of the nineteenth century. There are old crop workings on this horizon between Lower Oldtown eastwards to the edge of Braehead Moss, and again near Eastsidewood and Hardgate.

Crossbasket Ironstones of East Kilbride and High Blantyre.—North of Auchintibber and east of the River Calder clayband ironstones have been worked at several horizons, and are sometimes

referred to generally as the Crossbasket Ironstones.* They include the Whitestone Series (see p. 59), the New Seam (see p. 63) and the ironstone ribs above the Wee Post (or Foul Hosie) Limestone. With the latter alone we are concerned here, and the term Crossbasket Ironstones is used in this restricted sense.

A good exposure of this horizon can be seen on the west bank of the Calder, about 400 yds. N. of Calderwood Castle.† It shows some 45 ft. of blaes, containing 10 or more lenticular bands of ironstone up to 7 in. in thickness. The following section has been compiled from various sources :‡—

		Ft.	In.
No. 1 IRONSTONE	.	0	6
Blaes	.	about 6	0
No. 2 IRONSTONE	.	7 in. to 0	9
Blaes	.	about 9	0
IRONSTONE BALLS	.	3 or 0	4
Blaes	.	about 3	0
No. 3 IRONSTONE	.	7 in. to 0	10
Blaes and balls	.	13 to 15	0
WEE POST LIMESTONE			

These ironstones were wrought by mines along their outcrop in the Calder at a very early date.§

Pits were afterwards sunk to them on the east side of the Calder on Greenhall, Crossbasket and Blantyre. There must be a wide extent of these ironstones in the East Kilbride field, but little or nothing is known of them south of Auchintibber or west of the Calder. The little we do know, however, tends to emphasise their lenticular and impersistent character, and it is not likely they will attract attention as a source of ironstone in the near future.

Two analyses|| of these Crossbasket claybands may be quoted here. The first is of No. 3, the other of a "Ball Ironstone" which is no doubt the 3 or 4-in. "Ironstone balls" of the section given above.

	No. 3 Ironstone. Per cent.	Ball Ironstone. Per cent.
Iron	27·96	29·13
Carbonic acid	32·00	35·39
Silica	9·60	5·60
Alumina	5·56	2·85
Lime	4·70	9·18
Magnesia	5·76	...
Phosphoric acid	0·50	0·64

Boghead Claybands.—These ironstones, on the same horizon as the Crossbasket ones just described, were wrought in shallow pits

* Mushet, "On the Component Parts of Ironstones" (*circa* 1798–1800). See "Papers on Iron and Steel," 1840, p. 119, where some analyses of ores from the Crossbasket mines are given. See also "Statistical Account of Scotland," 1845, vol. vi., p. 317. Craig, *Trans. Highland and Agric. Soc.*, Second Series, vol. vi. (1839), p. 402.

† "Econ. Geol. Central Coalfield, Area VIII.," *Mem. Geol. Surv.*, 1917, p. 5.

‡ "Statistical Account," *loc. cit.*; Craig, *loc. cit.*; Patton, "Geological Observations on the Parish of East Kilbride," *Trans. Geol. Soc. Glasgow*, 1885, vol. vii., p. 314; Home Office, List of Abandoned Mines, Plan No. 1917.

§ See Mushet, *loc. cit.*

|| Kindly communicated by Messrs. Jas. Dunlop & Co. Ltd. of Clydronworks,

west of Boghead Limestone quarries, some $2\frac{1}{2}$ miles S.S.E. of Auchintibber (Lanark, 17 S.E.). They were one of the many sources from which the old Quarter Ironworks drew supplies of ore, but we have no record of the quality or extent of the seams. No. 4 Pit Boghead was $21\frac{1}{2}$ fms. deep to an 8-in. clayband.

Ironstones are also found in the Lennoxtown-Kilsyth strip of Carboniferous Limestone rocks above the Blackhall Limestone. They consist here of scattered clayband nodules which at one or two localities were in the old days collected at outcrops. To this horizon belong the septarian clayband nodules above the Blackhall Limestone at Corrieburn. These nodules were long ago collected there for the Carron Ironworks.*

LIMESTONE COAL GROUP.

Glasgow and Paisley District.

A detailed account of the geology of this area, mainly from an economic standpoint, will shortly be issued:† It includes the districts of Johnstone, Paisley, Renfrew, Govan, Hurlet, Thornliebank and Giffnock on the south side of the Clyde, and, to the north of the river, the Garscadden, Knightswood, Garscube, Springburn and Cadder fields. A general description of the geological features will be found in "Geology of the Glasgow District" (*Memoirs of the Geological Survey, Scotland*, 1911).

The Limestone Coal Group of the Glasgow district contains a considerable number of ironstone horizons, both blackbands and claybands. For convenience of description it has been divided into two subgroups called, after two well-known mining fields, the Garscadden and Possil Subgroups respectively; comparative vertical sections of these subgroups are given in Figs. 8 and 9. The Garscadden subgroup, extending from the Top Hosie Limestone to the Black Metals, is characterised by a marked development of blaes and clayband ironstones, and contains only one coal of workable thickness. This coal represents the well-known Coking Coal of Kilsyth; it has an average thickness of about 17 in., and so far has been wrought on a very small scale, only at Knightswood and Cardonald. The Possil subgroup, on the other hand, ranging from the top of the Black Metals to the Index Limestone, contains a number of valuable coal seams which are locally associated with blackband ironstones. Both subgroups contain ironstones of this nature, but these are much more characteristic of the upper one. To the latter belong the blackbands of Blaardardie, Jordanhill, Possil, Cadder, Pollokshaws and Giffnock; to the Garscadden subgroup belong the Upper and Lower Blackband horizons.

GARSCADDEN SUBGROUP.

Five important ironstone horizons are included here—the Johnstone Claybands, Garibaldi Claybands, Lower Blackband, Upper Blackband and the claybands of the Black Metals. (See Fig. 8.)

* See "Statistical Account of Scotland," 1792, vol. xviii., pp. 231-2.

† "Economic Geology of the Central Coalfield, Area IV." *Mem. Geol. Surv.* (in the press).

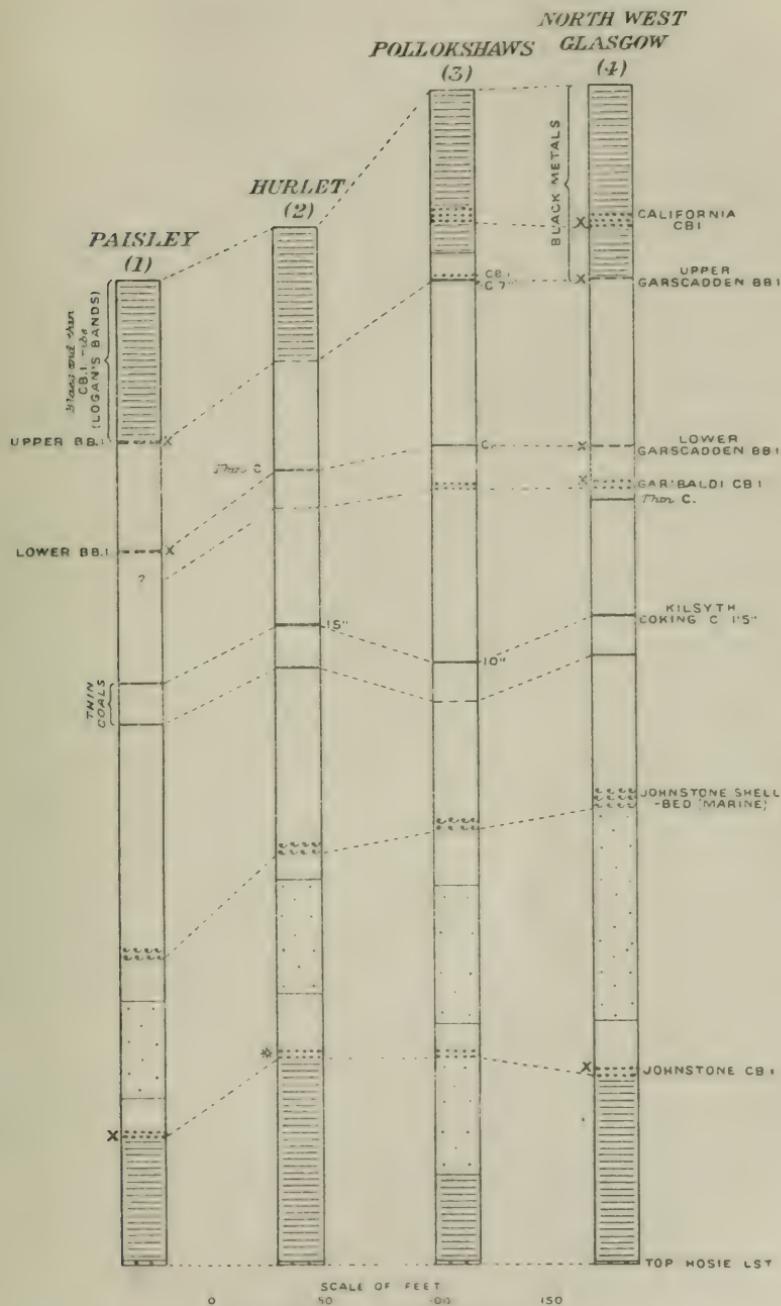


FIG. 8.—Comparative Vertical Sections of the lower part of the Limestone Coal Group in the Glasgow District. (Garscadden Sub-group.)

$C_s = C_{\text{obs}}$.

C. = Coal.
BB.I. = Blackband Ironstone.
CB.I. = Clayband Ironstone.

LST. = Limestone.

* Indicates seams at present worked
 ✓ Indicates seams formerly worked.

Johnstone Claybands.—These claybands constitute the lowest workable ironstone horizon in the Limestone Coal Group. They occur towards the top of the thick series of blaes overlying the highest of the Lower Limestones, and at a distance from it that decreases in a south-westerly direction from 15 to 9 fms. The latter figure applies to the Paisley-Johnstone field, and the thinning it indicates becomes even more marked farther south-west in the Caldwell-Lugton area* and in North Ayrshire. The claybands lie below the representative of the Kilsyth Coking Coal at a distance which varies from 34 fms. north of the Clyde to about 18 fms. south of the river at Pollokshaws, Cardonald and Hurlet.

An excellent index-mark for these claybands is furnished by the Johnstone Shell-bed, a richly fossiliferous bed of marine blaes lying 12 or 13 fms. under the Kilsyth Coking Coal position. This horizon occurs over the whole of the Paisley-Glasgow district, and is very readily recognised in bores from the richness of its fauna. It lies, north of the Clyde, about 21 fms. above the Johnstone Claybands, and south of it from 10 to 16 fms. above them.

(1) *South of the Clyde.*—For convenience of description the area occupied by these claybands south of the Clyde is divided into two subareas which lie north-west and south-east respectively of the marked crush-line known as the "Paisley Ruck." This curious belt of faulting and crushing runs past Quarrelton and Elderslie, crosses Paisley Racecourse and reaches the Clyde at the King's Inch, Renfrew. South-westwards it is continued through the Lochwinnoch Gap, and can be followed north-eastwards as far as Drumchapel.

Subarea (1) Johnstone to Renfrew.†—The chief basin in which the Johnstone Claybands are found here lies to the west of Paisley, and has its deepest point in the neighbourhood of Abercorn No. 2 Pit, where the ironstones are over 150 fms. deep. Between Inkermann and Newfield Farm (which lies N.W. of Johnstone) the workings in this horizon are practically continuous over an area of nearly 3 sq. miles. At the old Newfield, Fulton and Clippens Pits (Renfrew, 11 N.E.) the ironstones were worked to the outcrop, and farther east to the dip were raised from shafts at Burnbrae and Barbush and from the Abercorn, Candren and Douglas pits between Linwood and Inkermann (Renfrew, 12 N.W.). The sections of the Burnbrae and Abercorn workings were as follows—

	<i>Burnbrae.</i>		<i>Abercorn.</i>	
	Ft.	In.	Ft.	In.
Blaes roof			Blaes roof	
Blaes, brushing .	1½	to 2	0	
CLAYBAND .	2	in. to 0	6	
Blaes (18 to 36 in.) .	2		6	
Limestone .	0	1	Blaes .	2
CLAYBAND (10 to 16 in.) .	1	0	CLAYBAND .	6
Blaes pavement			1	0

On the east side of the basin the claybands reappear at the surface under Paisley Racecourse. Farther north, and on the down-throw side of the 40-fm. fault at Boghead (Renfrew, 8 S.W.), extensive workings have taken place from the Walkinshaw pits, east of the Black Cart. The same fault limits the workings from the

* See p. 18.

† Mainly from notes by Mr. R. G. Carruthers.

old Blackstone pits west of the Cart, where a considerable area was also wrought. The section at Walkinshaw was as follows:—

			Ft.	In.
Blaes .	.	.	0	0
CLAYBAND .	.	.	0	6
Blaes .	.	.	1	4
CLAYBAND .	.	.	0	5
Blaes .	.	.	0	9
CLAYBAND .	.	.	1	2
Blaes .	.	.	0	0

The 5-in. rib in the above section was crowded with iron pyrite concretions of the size of a pea, apparently of oolitic origin, and proved of no value as an ore. The Blackstone workings stopped in 1901, but the Walkinshaw Nos. 2 and 3 Pits did not close until 1914. The Walkinshaw workings extended as far north as the Black Cart between Walkinshaw House and Wester Yonderton, and at the latter place terminated against a 45-fm. upthrust fault (Renfrew, 8 S.W.).

Widely as the Johnstone Claybands have been worked in the Paisley district, there are one or two areas where reserves still exist. The horizon extends, for example, below a large part of Johnstone, as far south as the 50-fm. fault which passes through the centre of the village. Apart from the old Cartside Pit workings close to the railway junction, little seems to have been done here to the south of the Black Cart. There is, perhaps, 150 acres of the seam available here, but of this about a half is now built over. Another area, as yet unworked, lies to the north of Middleton Farm, half a mile west of Inkerman (Renfrew, 8 S.W.). This area is defined on the north by the 40-fm. fault already mentioned as terminating the Blackstone workings, on the east by the Black Cart, and on the west by the conjectural outcrop of the seam. There is, perhaps, 150 acres still to be worked here; a bore close to Middleton Farm records 16 in. of clayband at 61 fms. A small area still remains to be worked to the south of the abandoned Linclive-Abercorn workings, where there is perhaps 190 acres left. East of the Walkinshaw pits again there is still some Johnstone Clayband intact, but the seam is troubled and costly to work.

To the north of the large fault at Wester Yonderton the claybands reappear in a well-marked syncline around Townhead of Inchinnan (Renfrew, 8 N.W., S.W.). This syncline is sharply truncated to the north by the great east and west South Barr-Blythswood fault. There is an area of approximately 480 acres available in this basin. The only workings here were on a very small scale, from a pit near the deepest part of the field just south of Bottom Farm. This pit was 44 fms. deep, and a bore close to it records:—

			Ft.	In.
CLAYBAND .	.	.	0	9
Blaes .	.	.	2	9
CLAYBAND .	.	.	1	1

Another bore on the western edge of the basin, a little south of Greenhead Farm, gives practically the same section. A short distance west of the Inchinnan trough again there is yet another practically untouched area of the Johnstone seam. This area lies to

the north of Barnhill (Renfrew, 8 N.W., S.W.), and is let down between two large faults which converge in a northerly direction and almost meet before being cut off by the great east and west upthrust at South Barr. The more easterly of the two curves round in a south-westerly direction, passing through Wester Yonderton, and at Barnhill the two faults are about a mile apart. The only trial of the claybands in this area was made close to the smithy at Wardhouse, where a few acres were worked from a mine driven through the eastern fault (here about 70 fms.) from workings in the Hurlet Coal. The top clayband here was 6 in. thick, the main seam 12 in., and bores indicate that this is a fair average for the field. There is approximately 270 acres of ironstone here.

Subarea (2) East of Renfrew and Paisley.—To the east of the Inchinnan trough described above the outcrop of the Johnstone Clavband swings round the "nose" of the anticline of Calciferous Sandstone rocks which stretches northwards from Paisley towards Abbotsinch. It meets the line of crushing and faulting known as the "Paisley Ruck," and for some way east of that line the structure is somewhat obscure. The seam comes to the surface again west of Hillington and Cardonald (Renfrew, 8 S.E., 12 N.E.). At the old No. 1 Pit, Hillington, a little south-west of North Hillington Farm, the ironstone was worked over a small area by Messrs. Colin Dunlop & Company of the Quarter Iron Works. The seam was 26 fms. deep, and the dip was approximately 1 in 8 in a direction E. 15° S. A little farther east it was raised from Nos. 1 and 2 Pits, Cardonald, by Messrs. Jas. Dunlop & Company, from depths of 50 and 43 fms. respectively. The Cardonald workings began about 1876 and ceased in 1882; these at Hillington ceased in 1884. The sections of the seam showed:—

Cardonald.			Hillington.		
	Ft.	In.		Ft.	In.
Blaes roof			Blaes roof		
Blaes, brushing	. .	1 0	CLAYBAND	. .	0 10
CLAYBAND	. .	6 in. to 0 8	Blaes	. .	2 6
Blaes (holing)	. .	3 6	CLAYBAND	. .	1 0
CLAYBAND	. .	0 11	Blaes pavement		
Blaes pavement					

The clayband was also raised on the lands of Drumoyne up to 1882, where the depth to the seam at No. 3 Pit was 58½ fms. The main band of ironstone is said to have been 14 in. thick. In the unworked area around Moss Farm, near Cardonald Station, a bore records the following section at 48 fms.:—

	Ft.	In.
IRONY FAKES	. .	0 4½
Blaes	. .	2 8½
CLAYBAND	. .	0 11½
Blaes	. .	0 2
CLAYBAND	. .	0 1½

while two bores on Shieldhall show:—

	Ft.	In.		Ft.	In.
CLAYBAND	. .	0 8	CLAYBAND	. .	0 9
Blaes	. .	0 1	Blaes	. .	0 1
CLAYBAND	. .	0 4	CLAYBAND	. .	0 4
Blaes	. .	3 3	Blaes	. .	3 1
CLAYBAND	. .	1 1	CLAYBAND	. .	1 2

A trial pit was sunk at Shieldhall in 1868, but seems to have lain on or near the line of a 30-fm. fault which separates the un-worked ground around Cardonald Station from the Drumoynes field. South of Hillington the Johnstone Clayband appears to outcrop at Cardonald Mill, just east of Crookston Station (Renfrew, 12 N.E.), where an ironstone was formerly worked opencast on a small scale by the Carron Company. It underlies the whole of the Crookston Wood and Corkerhill area on the north side of the fault, passing under Hawkhead Asylum. The average section of the seam here is:—

	Ft. In.
CLAYBAND	6 in. or 0 8
Blaes, variable	3 6
CLAYBAND	1 1

In a bore near Crookston Castle it is 17 fms. deep. The Pollok Pit (Renfrew, 12 N.E.) of Messrs. Baird & Company was sunk in 1905 to work the Johnstone and Househill claybands, but was discontinued in 1914 on account of the cost of working the seams in faulted ground. The pumping machinery is still kept running, however, and the pit may yet resume operations.

Farther south still, in the Nitshill-Hurlet district (Renfrew, 12 S.E.), the Johnstone Clayband is still mined at the Victoria Pits.* The section of the seam, which here lies 80 fms. deep, is as follows:—

	Ft. In.
CLAYBAND	0 8
Blaes	2 ft. 9 in. to 4 6
CLAYBAND	1 0

The present output from the Johnstone seam at this pit is approximately 60–70 tons a day. Here, again, future workings are likely to be limited by the presence of faults.

South and east of these districts very little is known of the development of this seam. It must underlie the whole of the Govan, Ibrox, Pollokshaws, Thornliebank and Giffnock fields. It no doubt thins away eastwards as it does north of the Clyde, and we know it has no economic value in the East Kilbride field. In the deep Titwood bore, near Maxwell Park Station, it showed at a depth of nearly 100 fms.:—

	Ft. In.
CLAYBAND	0 2
Blaes	2 4
LIMY CLAYBAND	1 3

(2) *North of the Clyde.*—The Johnstone Claybands were worked to a small extent in the Garscadden and Knightswood fields. At Garscadden they were wrought (1872–84), under the name of the Lower Clayband, over a considerable area between Castlehill and Townhead (Dumbarton, 23 S.E.). The working section recorded shows:—

	Ft. In.
Blaes roof	1 6
Blaes, brushing	6 in. to 0 9
CLAYBAND	2 ft. to 2 9
Blaes	7 in. to 1 0
CLAYBAND	

* For analysis see p. 75.

A small area near No. 10 Pit, Knightswood, was opened out in 1879, and again apparently in 1886. The section here was:—

	Ft.	In.
Blaes roof	.	0
TOPS	1	0
Blaes	2	10
CLAYBAND	0	9
Blaes	0	1
Rough stone	0	5
Blaes pavement		

Here it went by the name of the Dalry Clayband, and at No. 10 Pit was $97\frac{2}{3}$ fms. deep (Dumbarton, 25 N.E.).

Nowhere else have these ironstones been worked north of the Clyde, and all our additional information regarding their development here is derived from bores. There is little doubt that they exist in a workable condition as far east as Maryhill. To the west the outcrop forms an irregular line running from Yoker northwards by East Kilbowie and Braidfield; it then meets a N.E.-S.W. upthrow fault, on the north side of which it reappears near South Mains Farm. At the old Prince Albert Pit to the Hurlet Coal (about 1 mile S.E. of Duntocher), the Johnstone Claybands were proved at a depth of 31 fms. (or $63\frac{1}{2}$ fms. above the Hurlet Coal). The horizon showed:—

	Ft.	In.
CLAYBAND	0	8
Blaes	4	0
CLAYBAND	0	10
Blaes	2	8
CLAYBAND	0	10
Blaes	4	4
CLAYBAND	0	8

At West Drumchapel and at Knightswood bores record:—

West Drumchapel.

	Ft.	In.
CLAYBAND	0	9
Blaes	2	11
CLAYBAND	1	4

Knightswood.

	Ft.	In.
CLAYBAND	4 in.	to 1
Blaes	2 ft.	9 in. to 4
CLAYBAND	7 in.	to 1

A bore a little S.E. of Bonnaughton Farm records:—

	Ft.	In.
CLAYBAND	0	6
Blaes	2	11
CLAYBAND	0	9

and near South Mains (Dumbarton, 23 S.E.) the main band is given in bores as 10 to 14 in. thick. Two sections are recorded in the Maryhill district (Lanark, 6 N.W.).

No. 1 Bore Balyray (before 1865).

	Ft.	In.
Hard sandy "band"	0	9
Blaes	2	0
LIMY CLAYBAND	1	4
HARDER CLAYBAND	0	5

No. 16 Bore Hyndland (1878).

	Ft.	In.
CLAYBAND	1	0
Blaes	2	0
CLAYBAND	1	1

Farther east still, at Springburn and Cadder, the Johnstone Clayband is poorly developed and has no economic value.

The following analyses of calcined Johnstone Clayband will illustrate the nature of this seam :—

	Walkinshaw.*		Nitshill.*	Cardonald.+
	1903-1911.	Average.		
	Per cent.	Per cent.	Per cent.	Per cent.
Iron (metallic)	40 to 44	42·00	43·76	45·88
Silica	12 to 17	13·95	14·43	12·93
Alumina	7 to 11	9·46	7·60	8·73
Lime	6·5 to 9·0	7·71	5·45	5·82
Manganese	1·0 to 1·6	1·28	1·20	—
Magnesia	2·0 to 4·5	3·26	4·89	—
Phosphorus	·75 to 1·00	0·90	0·87	1·3
Sulphur	·15 to ·30	0·21	0·16	—

New Jordanhill Blackband (=Garibaldi Coal).—This name was applied to a blackband ironstone met with in 1879 in proving a 16-ft. downthrow in the workings of the Garibaldi Ironstone at No. 8 Pit, Jordanhill. It lay about 1½ fms. under the Garibaldi Ironstone, and was worked only over a very small area. The section of the seam showed :—

	Ft.	In.
Fakes roof		
Blaes	1	6
STONE, streaked with coal	0	4
BLACKBAND	0	6
Sandstone pavement		

The "stone" of this section was no doubt an ironstone, as the full thickness of the seam wrought was 9 to 13 in.

The occurrence of blackband at this horizon was purely local. Everywhere else, so far as is known, there is present in this position a thin coal of 8 to 16 in., which may conveniently be referred to as the Garibaldi Coal.

Garibaldi Claybands.—The Garibaldi Claybands (so named at Jordanhill in 1860 after the Italian hero) lie 3 fms. below the Lower Blackband, and about 9 above the representative of the Kilsyth Coking Coal. They occur near the base of a fairly thick bed of blaes, and a few feet below them there is very constantly a thin coal of 8 to 16 in. known as the Garibaldi Coal.

This horizon has a wide distribution in the Glasgow district, and extends north-eastwards into the Kilsyth and Banton fields, where the ironstones have also been locally wrought (see p. 91).

(1) *North of Clyde.*—The area over which the Garibaldi Claybands have been worked is very much the same as that of the Upper Blackband, and extends from Garscadden south-eastwards to Gartnavel. The workings in this seam continued up to about 1892. It was extensively

* Communicated by Messrs. D. Colville & Sons Ltd., Glengarnock.

+ Communicated by J. Buchanan, Esq., of Clyde Iron Works.

wrought at Knightswood, Jordanhill, Cloberhill and Skaterigg, where it showed the following average section :—

		Ft.	In.
Blaes roof	.	2	0
Blaes, brushing	.	4 in. to 0	6
CLAYBAND	.	about 2	9
Blaes	.	6 in. to 0	8
CLAYBAND	.		
Blaes pavement	.		

It was regarded as a clayband of excellent quality. An analysis of the charred ore from Jordanhill showed :—

		Per cent.
Iron	.	38·92
Insoluble	.	20·70
Manganese oxide	.	0·52
Phosphorus	.	0·66
Sulphur	.	0·30
Silica	.	14·80

East of Skaterigg again it was wrought over a considerable area in the Gartnavel-Balgray field as far as the R. Kelvin at Kelvindale House. The seam showed :—

		Ft.	In.
CLAYBAND	.	0	6
Blaes	.	2	9
Lime	.	0	1½
CLAYBAND	.	0	6

with a blaes roof and pavement as usual.

North of the Gartnavel field a very small area of the Garibaldi Ironstone was opened at Garscube, just south and west of No. 1 Pit. The section was much the same as that given above, but the limestone rib reached 4 in., and the lower 3 or 4 in. of the bottom clayband proved poor in quality. East of Balgray again the Garibaldi Ironstone was raised from several pits in the Eastpark district of Maryhill where thicknesses of 10 to 12 in. are recorded in the shafts. Of the extent of these workings very little is known, and the ground is now almost completely built over.

At Hamiltonhill the Garibaldi Ironstone is recorded as 10½ in. thick in two plies separated by 3 ft. of blaes, but from that locality south-westwards to the Clyde at Partick nothing is known of its development.

There is an untouched area of these claybands to the north and north-east of Garscube, but the seam has not often been proved in this district. In three bores at Chapelton, a little south-east of Bearsden, it shows :—

CLAYBAND	.	.	.	.	5 to 6 in.
Blaes	:	:	:	:	2 ft. 7 in.
CLAYBAND	:	:	:	:	7 to 9 in.

At Boclair and Dougalston Loch, 1½ miles north of Chapelton, bores give—

CLAYBAND	.	.	.	.	2 to 6 in.
Blaes	:	:	:	:	about 3 ft.
CLAYBAND	:	:	:	:	5 or 6 in.

In the Lambhill-Cadger area it seems to vary somewhat, but probably averages 9 to 12 in. of ironstone in two plies.

Westwards again at Drumchapel and Garscadden the Garibaldi Claybands are rather thinner. At Garscadden a few small areas were opened out about 1870-80, and the section on the plan of the workings records :—

	Ft. In.
TOP STONE	0 4
Blaes	2 9
BOTTOM STONE	0 3
Blaes	4 in. to 1 6
FREE COAL	0 6

A blind bore in No. 3 Pit, Drumchapel, shows :—

	Ft. In.
CLAYBAND	0 7
Blaes	3 1
CLAYBAND	0 10

but west of Drumchapel Station again the top ply is recorded as 3 to 6 in. and the bottom one as 5 to 6 in.

(2) *South of Clyde*.—The Garibaldi Claybands have been worked to a slight extent at Drumoyne and Ibrox where they showed :—

	Ft. In.
Blaes	
CLAYBAND	0 4
Blaes	2 ft. 3 in. to 3 0
CLAYBAND	0 6
Blaes	

It seems to be very poor at Cardonald. In the Blythswood trough two bores record :—

CLAYBAND, 2½ in. and 4 in.
Blaes, 20½ in. and 26 in.
CLAYBAND, 7½ in. and 4½ in.

It has an extremely poor development in the Paisley district, and is not even recorded in several bores.

The only record of this horizon in the Pollokshaws district occurs in the deep Titwood bore near Maxwell Park Station, where the Garibaldi is represented by ironstone ribs of 2 to 3 in.

Lower Garscadden Blackband.—The Lower Garscadden Blackband (or Govan Blackband) lies 10 to 13 fms. under the Upper Blackband. It occurs near the middle of a thick bed of blaes towards the base of which are found the Garibaldi Claybands, and about 3 fms. above the latter.

The Lower Blackband has a very much wider distribution than the Upper. It has been wrought in the Glasgow district both north and south of the Clyde, and is represented in the Kilsyth-Banton field by the well-known Banton Blackband (see p. 91). Even in these areas, however, it is only of local occurrence as a workable subject.

(1) *North of the Clyde*.—This seam was wrought in the Garscadden field from 1863 to 1884 approximately (Garscadden, Hutcheson and Gartconnel pits). About eight different areas were opened out and worked, so that even here the seam appears to have

been patchy in character. The section given on the plan of the old workings shows:—

	Ft. In.
Blaes roof	
BLACKBAND	0 5
COAL	0 4
Blaes	2 2
Blaes pavement	

Bores put down to prove the seam prior to the working of it recorded thicknesses of 8, 9, 11 and even 13 in. of blackband resting on an inch or two of coal.

South-east and south of Garscadden, in the Drumchapel field, the Lower Blackband is represented by a 6 to 8-in. coal with a 2 to 6-in. blackband occurring locally above it.

Elsewhere north of the Clyde, at Knightswood, Jordanhill, Garscube, Maryhill, Hamiltonhill, etc., it is represented by a thin 8 to 14-in. coal with an ironstone rib 2 or 3 in. thick above it.

(2) *South of the Clyde.*—The Lower Blackband has been worked at Ibrox and in the Linwood district to the west of Paisley. At Ibrox it was wrought over a considerable area between Ibrox Hill and Drumoyne. In one of the old pits at Drumoyne it is recorded as gas coal 10 in., overlying blackband 9 in., but farther south-east at Craigton, Ibrox and Ibroxholm it showed the following section:—

	Ft. In.
Blaes roof	
Irony blaes	4 in. to 1 2
BLACKBAND	(9 to 14 in.) 1 1
COAL	1 in. to 0 3
Black blaes	1 0
Blaes pavement	

North-east of these old workings, in the Govan district, the Lower Blackband is present in workable thickness. A bore at Moorepark records $1\frac{1}{2}$ ft. of blackband at 68 fms. and another at Govan Forge 12 in. at $\frac{7}{5}$ fms. Of its development east and north-east of Govan nothing appears to be known. To the south-east of Ibrox Hill it seems to deteriorate; in a bore a little west of Maxwell Park Station it is represented by two 2-inch ribs of "coarse ironstone" overlying coaly blaes, while in the deep Titwood boring just south-east of the station it is present as a 17-in. coal. It may be added here that the blackband at Ibrox showed a large number of "wants," some of considerable size. West of the outcrop at Drumoyne and Craigton the blackband is faulted down again and is present around Merryflats and Cardonald Station; in bores on Moss Farm, just west of the station, the seam is only 3 or 4 in. thick. To the south-east the seam must underlie Craigton Cemetery, Halfwayhouse and all the ground west of Corkerhill. A bore on Henderston, a little south of Halfwayhouse, records $15\frac{1}{2}$ in. of soft coal, but this and the Titwood boring already mentioned are practically all the evidence we have regarding its development here. In a bore put down beside the Hole Burn, 500 yds. east-by-south from Nether Auldhouse, the Lower Blackband position was proved but no ironstone found.

An area of the Lower Blackband occurs farther west at Blythswood, to the north-west of Renfrew. The outcrop of the seam runs

from Bottom to Portnauld farms, and the shallower part of the field has been entirely wrought out. East of the Black Cart the ironstone lay deeper with a steady dip to the S.E., and was wrought over a small area from No. 4 Pit, Blythswood. No section of the workings is available, but an old bore records 17 in. of blackband. The field itself is defined to N.E. and S.W. by large faults, and forms a trough about a third of a mile in width: it is unlikely, judging from the evidence available, to extend far eastwards, the two boundary faults probably joining at Renfrew.

In the Paisley-Johnstone district again the Lower Blackband was largely worked in former years. Round Linwood it occupied a well-marked syncline truncated on the S.E. by the crush-line known as the "Paisley Ruck."* Owing to the somewhat high dip, the seam in the centre of the basin at the Abercorn pits lay at a depth of over 110 fms. The workings were carried right to the outcrop, and the seam showed 7 to 12 in. of blackband on a few inches of coal or coaly daugh. In the Abercorn pits thicknesses varying from 6 to as much as 20 in. occurred, and in the little field at Boghead to the north it was approximately the same. On the north side of the 40-fathom fault at Boghead the Lower Blackband was extensively wrought between Blackstone House and Mosside. Near Wester Walkingshaw the seam was 15 in., but when the workings stopped close to Mosside it had dwindled to 6 and even to 2 in.

The Lower Blackband may be regarded as practically exhausted in the Paisley district.

Upper Garscadden Blackband.—The Upper Garscadden Blackband lies at the base of the thick series of blaes and ironstone ribs known as the Black Metals. It is of local occurrence only, and even where worked proved thin and variable.

(1) *North of the Clyde.*—The area over which this seam has been found workable extends roughly from Garscadden south-eastwards to Garscube and Gartnavel. It was raised over a considerable area in the Jordanhall, Skaterigg, Knightswood and Cloberhill district, where it showed the following:—

	Ft. In.
Blaes roof	
Blaes (with a 2 to 3-in. clayband rib), brushing	2 0
Blaes	1 9
Blacks	0 3
BLACKBAND	(7 to 13 in.) 0 9
Sandstone pavement	

It was last worked about 1894–6 from No. 12 Pit, Knightswood.

It is not found in workable thickness at Drumchapel, where bores record it as a 3 to 8-in. coal, but farther north-west in the Garscadden field it was worked for over 20 years. Here it showed:—

	Ft. In.
Blaes roof	
Blaes, brushing	2 0
Blaes	1 10
BLACKBAND	8 in. to 0 11
COAL, locally	0 1
Sandstone pavement	

* See p. 70.

The Upper Blackband was also wrought over a considerable area at Garscubie Colliery, the workings extending across the River Kelvin towards Acre. The seam here showed:—

	Ft. In.
Blaes and balls	
Blaes	2 0
GAS COAL	0 3
BLACKBAND	(4 to 9 in.) 0 7
Sandstone pavement	

The ironstone was thickest to the west of the pits.

It was worked a little also from Gartnavel No. 7 Pit, but was only $6\frac{1}{2}$ in. and thinned to the east. Farther east again at Maryhill, Lambhill and Hamiltonhill it is represented by a thin foul coal or coaly blaes, with an inch or two of ironstone atop. It is poor again at Chapelton, a little S.E. of Bearsden, where bores record 5 or 6 in. of "ironstone" on a thin coal.

There is therefore little, if any, of this seam left of workable thickness. A small area may exist between Garscubie Mill and Acre (6-in. Lanark, 1 S.W. or Dumbarton, 25 N.E.).

(2) *South of the Clyde*.—The Upper Blackband is very poorly developed here. At No. 2 Pit, Abercorn, in the Linclive basin to the west of Paisley it was worked to some extent, and is given in the shaft section as 12 in. thick; in the workings, however, thicknesses of 6 in. are recorded. Elsewhere south of the Clyde the seam has attracted no attention. In the Ibrox district it is represented by a few inches of dross coal or coaly blaes, and in the deep Titwood Bore at Maxwell Park Station by two ironstone ribs of 3 and 4 in. in thickness overlying 7 in. of coal.

California Claybands of the Black Metals.—The term Black Metals is applied to the thick series of blaes containing ribs and balls of clayband ironstone which occurs in the Central Coalfield about the middle of the Limestone Coal Group. The associated claybands, more particularly in the lower part of the blaes, have been found locally of workable thickness. The following names have been used to designate them in different localities.

North Ayrshire and Renfrewshire—Logan's Bands (see pp. 19, 23, 32).

Glasgow District—California Claybands.

Kilsyth, etc.—Banton Claybands (p. 94).

Wilsontown District—Hogg Fence Ironstones (p. 102).

Carlisle District—Maggie Bands (p. 104).

Most of the claybands in the Black Metals of the Glasgow district vary from 2 to 6 in., but one or two of them show thicknesses of from 9 to 14 in. Those wrought in this part of the Central Coalfield lie 3 or 4 fms. above the base of the Black Metals, which is here defined by the Upper Garscadden Blackband Ironstone.

(1) *North of the Clyde*.—Claybands in this position were formerly wrought at Gartnavel, and the term "California" was given them in the early sixties. Later the same horizon was opened out at Garscubie Colliery, but was proved too thin to work. The section at Garscubie is recorded as follows:—

	Ft. In.
Blaes and balls	
California stone	0 9
Blaes	1 3
CLAYBAND	0 5
Blaes	1 3
CLAYBAND	5 in. or 0 6

The lower rib is said to have been of poor quality here. A considerable number of bores have passed through this horizon in the N.W. Glasgow district, at Garscadden, Knightswood, Garscube, etc. An analysis of these brings out the fact that over a large area this horizon shows from 10 to 16 in. of ironstone in a 3 to 4-ft. blaes working. Locally there may be 18, 20, or even 22 in. The ironstone occurs in two or occasionally three ribs which individually seldom exceed 8 or 9 in. A rough estimate of the area occupied by this clayband horizon in the N.W. suburbs of Glasgow gives approximately 9600 acres. With an average thickness of 12 in. of clayband, which is perhaps too low, and a specific gravity of 3, the total available ore is roughly 34½ million tons.

To the north-east of Glasgow again, in the Springburn, Robroyston and Chryston districts, there is another large field of the California Claybands. Available bores here indicate a total thickness of 15 to 17 in. of clayband in a 4 to 5-ft. blaes working.

(2) *South of the Clyde*.—In the country lying east of Paisley and south-west of Glasgow the Black Metals are represented by 10 or 12 fms. of blaes containing ribs of clayband ironstone which in some cases reach a thickness of 15 in. A fair number of bores record a workable series of ironstones some 2 or 3 fms. above the base of the Black Metals in the position of the California Claybands north of the Clyde.

The data from three of these bores are given below:—(1) Bore to east of East Henderston (Renfrew, 13 N.W.); (2) Titwood deep bore (Lanark, 10 N.W.); (3) Bore on the Hole Burn near Nether Auldhouse, Pollokshaws (Renfrew, 13 S.W.).

(1)	Ft. In.	(2)	Ft. In.	(3)	Ft. In.
Coarse iron pyrites	0 5	IRONSTONE	0 5	IRONSTONE	0 4
IRONSTONE	0 5½	Blaes	1 9	Blaes	1 9
Dark blaes	0 9	IRONSTONE	1 1	IRONSTONE	1 3
IRON RIB	0 3	Blaes	0 10	Blaes	2 0
Dark blaes	1 0	IRONSTONE	0 3	IRONSTONE	0 5
IRONSTONE	0 5	Blaes	1 7		
Dark blaes	2 10	IRONSTONE	0 6		
IRONSTONE	0 6				

These three sections are all approximately on the same horizon, and suggest the existence of an ironstone field which may merit some attention in the future.

In the Paisley-Johnstone district the ironstones of the Black Metals are known more generally as Logan's Bands, a name derived from the Kilbirnie field (see p. 23). They form along with the associated blaes a constant and readily recognised horizon 12 to 15 fms. thick, but the clayband ribs themselves have not yet proved of economic value.

POSSIL SUBGROUP (see FIG. 9).

(1) *North of the Clyde.*—The blackband ironstones that fall to be described next are lenticular impersistent deposits characteristically associated with ribs of gas coal. A very common association is:—

Parrot or gas coal.
Blackband.
Parrot or gas coal.
Free coal.

The ironstone dies away laterally, but the accompanying coal may thicken and persist over wide areas as a workable subject. The accumulation of the materials which now form these blackband ores took place in more or less isolated lagoon-like areas of deposition, the main axes of which appear to have had a N.E.-S.W. trend. A feature of some interest is the recurrence of the same physical conditions in the same districts, so that at one locality we may find blackbands developed at two or three horizons not far apart, while in a closely adjoining district they may be all absent. As an instance of this may be cited the three ironstones of the Cadder field.

These blackbands vary very much from point to point both in thickness and character. Generally speaking they are thin, although very locally thicknesses of 3, 4 or even 7 ft. may be found in "pockets." Often they are only of value from their association with a workable coal.

Old Jordanhill Blackband.—The geological position of this seam is 4 or 5 fms. above the Knightswood Gas Coal. It is developed as a blackband only in the Jordanhill-Skaterigg field. Although previously sunk through in four pits, its value as an iron ore was not discovered until about 1837, and in the earlier records it is termed the "drugget stone." M'Lennan* states that it averaged 18 in., and yielded an ore of excellent quality. The seam was found to persist as a blackband across the Skaterigg march into the western part of the Gartnavel-Balgray field, but was considerably thinner here, and rapidly passed eastwards into a 12 to 15-in. coal. The sections of the seam at Skaterigg Engine Pit and at Gartnavel No. 2 Pit are recorded as follows:—

Skaterigg.			Gartnavel.		
	Ft.	In.		Ft.	In.
PARROT COAL . . .	0	4	PARROT COAL . . .	0	3
BLACKBAND 10 in. to . . .	1	4	BLACKBAND . . .	0	9
COAL . . .	0	4	COAL . . .	0	5

In one of the Glasgow Iron Company's old ironstone pits at Eastpark, Maryhill (Lanark, 6 N.W.), the Jordanhill Blackband is represented by a 22-in. free coal, and at Hamiltonhill by 18 in. of coal. A 2-ft. coal on the same horizon was wrought at Garscube as the Jubilee Coal, and a coal occupies the same position at Cloberhill, Drumchapel, Garscadden, etc.

Between 1837 and 1867 it was completely worked out.

Lower Possil Blackband.—This blackband lies 2 or 3 fms. below the Main Coal. It is found only in the ground between Eastpark (Maryhill) and Springburn. Three sections are given on p. 84:—

* *Trans. Geol. Soc. Glasgow*, vol. viii., 1887, p. 273.

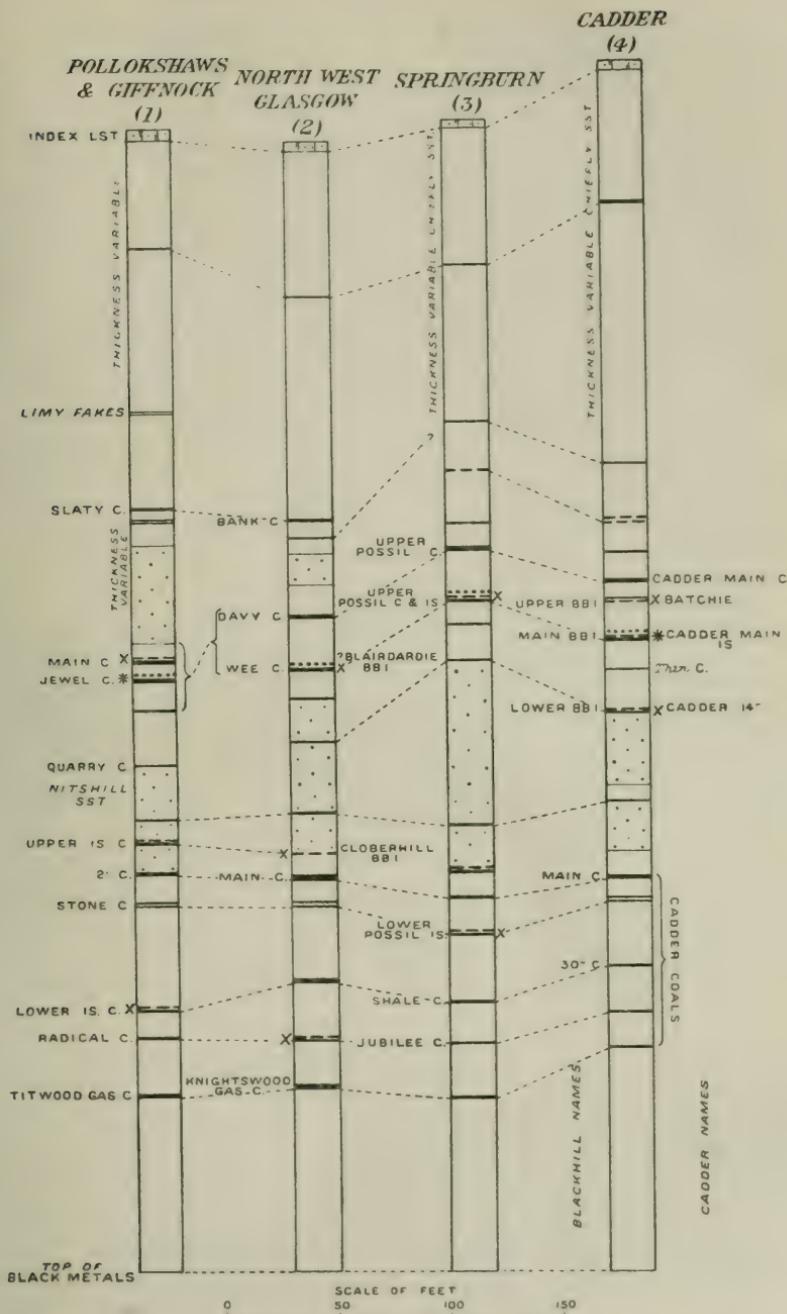


FIG. 9.—Comparative Vertical Sections of the upper part of Limestone Coal Group in the Glasgow District. (Possil Sub-group.)

C. = Coal.

IS. = Ironstone.

BB.I. = Blackband Ironstone.

* Indicates seams at present worked.

LST. = Limestone.

SST. = Sandstone.

× Indicates seams formerly worked.

(1) Eastpark, "New Ironstone Pit," 1868 (Lanark, 6 N.W.); (2) Hamiltonhill (Lanark, 6 N.W.); and (3) No. 1 Pit Saracen, Springburn (Lanark, 6 N.E.).

(1)	Ft. In.	(2)		(3)	
		Ft.	In.	Ft.	In.
PARROT .	0 2	PARROT .	0 3	Blaes	
BLACKBAND .	0 2	BLACKBAND .	0 9	BLACKBAND .	0 5
Fireclay .	3 10	Dirt .	0 2	Dirt .	0 5
Sandstone .	1 6	COAL .	0 11	COAL .	1 0
COAL .	1 1				

The ironstone was formerly wrought in the Hamiltonhill and Saracen pits, and as a workable blackband is confined to this area. The sections at (1) Gartnavel No. 2 Pit, and (2) Skaterigg Engine Pit may be quoted by way of illustrating its development elsewhere.

(1)	Ft. In.	(2)		Ft. In.
		Ft.	In.	
COAL .	0 9	COAL .	.	1 2
COAL and daugh .	1 0	Strata .	.	1 8
DOGGER (? ironstone)	0 2	IRONSTONE BALLS .	.	0 4
Daugh .	0 3	COAL .	.	1 0
COAL .	0 10			

Elsewhere the Lower Possil Blackband is represented by a coal, e.g. at Cloberhill, Drumchapel, Garscube, Lambhill, Bishopbriggs, etc.

Cloberhill Blackband (or "Wee Stone").—One or two fathoms above the Main Coal there is very generally a thin coal position which locally is developed as a blackband seam. As such it is practically confined to Knightswood and Cloberhill, where it was formerly wrought on a small scale. The section of the seam at Cloberhill, where it lay 44 fms. above the Upper Garscadden Blackband, was as follows:—

		Ft. In.
Blaes roof		
Craw .	.	1 6
BLACKBAND .	.	0 4
Blacks .	.	0 4
BLACKBAND .	.	0 2
COAL .	.	0 3

The area where it was wrought lies around Cowdenhill Farm (Dumbarton, 25 N.E.).

Sections of the same horizon at (1) Skaterigg Engine Pit, (2) Gartnavel No. 2 Pit, and (3) Eastpark are as follows:—

(1)	Ft. In.	(2)		(3)	
		Ft.	In.	Ft.	In.
BLACKBAND .	0 4	Slaty blaes .	1 0	PARROT COAL .	0 5
FREE COAL .	1 0	Black blaes .	1 0	BLACKBAND .	0 3
		SOFT COAL .	1 0	FREE COAL .	1 1

Elsewhere the horizon appears to be represented by a thin coal with an iron parrot or thin ironstone above it. This coal is poorly represented at Drumchapel but thickens eastwards, and is about 15 in. thick in the Lambhill-Bishopbriggs area. At Skaterigg it was given the name of the "King Coal." Locally a rib of blackband, 2 or 3 in. thick, is associated with it.

We come now to a group of coals and blackband ironstones which are somewhat more difficult to describe. The lower limit of this group lies about 10 fms. above the Main coal (Knightswood, etc., Main), and the upper limit some 15 fms. higher. It includes the Blairdardie and Drumchapel Blackbands, the Davy and Wee Coals of Garscube, the Upper Possil Coal and Upper Possil Ironstone, the Cadder Main Coal, and the three Cadder Blackbands (the Batchie, Main, and 14-in.). The local development of the blackbands renders exact correlation a matter of some difficulty, and it is a further source of confusion that the same seam has been worked at neighbouring collieries under different names. The following table shows the nomenclature adopted in various parts of the district:—

<i>Springburn and Hamiltonhill.</i>	<i>Gilslochhill.</i>	<i>Blackhill.</i>	<i>Kenmure.</i>	<i>Cadder.</i>
Upper Possil Coal 1 fm. (Thin Coal) 3 fms.	Upper Possil Coal $1\frac{1}{2}$ fms. Upper Black- band 4 fms.	Upper Possil Coal 1 fm. Upper Black- band (Wee Stone) $4\frac{1}{2}$ fms.	Upper Possil Coal $1\frac{1}{2}$ fms. (Parrot Coal) $3\frac{1}{2}$ fms.	Cadder Main Coal $1\frac{1}{2}$ fms. Batchie IS. 3 fms.
Upper Possil B.B. $4\frac{1}{2}$ fms. (Thin Coal)	Coal with 4- in. clay- band on top ...	Main or Middle B.B. 5 fms. Lower Black- band	Upper Possil or Main B.B. $3\frac{1}{2}$ fms. Understone	Cadder Main IS. 5 fms. 14-inch IS.

Cadder 14-in. Ironstone.—This seam lies about 5 fms. below the Cadder Main Ironstone. It is developed as a blackband in the ground extending from Cadder south-westwards towards Blackhill. Characteristically it shows:—

Dark blaes
PARROT COAL, 4 to 11 in.
BLACKBAND, 6 to 14 in.
COAL, a few inches.

It varies very much from point to point; where the blackband is thickest, the parrot coal tends to thin away, and the underlying rib of coal is, towards the west, separated from the rest of the seam by a foot or two of fakes. South of the Forth and Clyde Canal, on the lands of Kenmure, a seam lying $3\frac{1}{2}$ fms. below the Main Ironstone was wrought over a small area near No. 14 Pit (Lanark, 1 S.E.). It was known as the Kenmure Understone, and showed:—

			Ft.	In.
Blaes	.	.	1	1
IRONSTONE (Blackband)	.	.	0	$11\frac{1}{2}$
Fakes	.	.	0	$6\frac{1}{2}$
PARROT	.	.	0	$9\frac{1}{2}$
Fakes	.	.	0	$4\frac{1}{2}$
Sandstone pavement				

This seam lies on the same horizon as the Cadder 14-in. The Lower Blackband of the Blackhill field, lying 5 fms. under the Main Ironstone, occupies the same geological position. The section of this seam, as wrought about 1862-75 in the old pits half a mile east of Blackhill Farm (Lanark, 1 S.W.), showed:—

	Ft. In.
Blaes roof	
BLACKBAND	0 11
Blaes	0 8
FOUL COAL	0 6
Daugh	0 1
Sandstone pavement	

Upper Possil Ironstone (Cadder Main Ironstone, Blackhill Main or Middle Blackband).—The Upper Possil Ironstone and Coal seam was extensively worked in the area stretching from Possil Park and Lambhill eastwards to Robroyston. It was raised in pits at Hamiltonhill, Possil, Overpossil, Coltpark, Crowhill, Springfield, Mosesfield, Balornock and Robroyston (see 6-in. Sheets Lanark, 1 S.W., S.E.; 6 N.W., N.E.). The seam was very regular in character, and the average section showed:—

	Ft. In.
Blaes	
CLAYBAND	0 3
Blaes (9 to 15 in.)	1 2
BLACKBAND	4 in. or 0 5
COAL	1 6
Sandstone or fakes pavement	

These figures are taken from sections of the old workings. Locally a 2 to 3-in. parrot coal overlies the blackband, and sometimes an inch or two of parrot is recorded immediately below it. The Upper Possil Ironstone and Coal was also raised on Kenmure from the Summerlee Iron Co.'s Nos. 12 and 13 Pits close to Brackenbrae. Half a mile to the north-west it was worked on the south side of the Forth and Clyde Canal from Nos. 14 and 15 Pits, under the name of the Kenmure Main Blackband. The sections at these localities were:—

<i>Nos. 12 and 13 Pits.</i>		<i>Nos. 14 and 15 Pits.</i>	
	Ft. In.		Ft. In.
Blaes		Blaes	
IRONSTONE (? clayband)	0 4	CLAYBAND	0 3
Blaes	1 1½	Blaes	1 1
IRONSTONE (blackband)	0 4	STONE (blackband)	0 8
COAL	1 5	{ COAL	0 5
		Dogger	0 5
Sandstone		COAL	0 1
		Sandstone	

Between these workings and Littlehill Farm the Main (or Upper Possil) Ironstone was widely wrought up to 1888 by the Carron Company from Nos. 10, 12, 14, etc., pits. The seam here showed:—

	Ft. In.
Blaes	
CLAYBAND	0 3
Blaes	0 10
BLACKBAND	2 in. to 0 4
COAL	1 ft. to 1 7

The same seam was also wrought from No. 16 Pit around Westerhill and Rushyhill, where a 2½-in. wild coal is recorded above the blackband.

The Main Ironstone is still being wrought from the Carron Company's No. 17 Pit, where an average section of the workings shows :—

	In.
CLAYBAND	2 to 4
Dark blaes	9 to 16
PARROT COAL	3
BLACKBAND	5 to 10
ROUGH COAL	9 to 20
IRONY PARROT OR BLACKBAND	2 to 7

This seam has also been worked by the Summerlee Iron Co. at Blackhill, both in the old No. 5 Pit lying half a mile east of Blackhill Farm, and until recently in the present pits (Lanark, 1 S.W.). At the old No. 5 Pit, abandoned 1875, the section of the seam was :—

	Ft. In.
Blaes	
IRONSTONE	0 4
Blaes	1 6
IRONSTONE (blackband)	0 4
PARROT COAL	0 1½
COAL	1 1
Fakes	

At Blackhill this horizon was known as the Middle or Main Blackband, to distinguish it from the Upper (=Batchie) and Lower (=14-in.) Blackbands (see Table on p. 85). At Gilslochhill, again, the seam wrought under the name of the Upper Possil Blackband (see Home Office List of Abandoned Mines, No. 4167) corresponds in reality to the Upper Blackband of Blackhill. The true Upper Possil Ironstone (or Cadder Main Ironstone) of the Gilslochhill field is represented by an unnamed coal lying 5½ fms. below the Upper Possil Coal. This unnamed seam was worked on a small scale at Gilshochhill, and showed :—

CLAYBAND, 4 in.
COAL, 28 in.

The following analysis of the clayband rib at Balornock has been kindly communicated by J. Buchanan, Esq., of Clyde Iron Works :—

	Per cent.
FeO	43·04
Fe ₂ O ₃	0·36
SiO ₂	11·20
MgO	3·30
CaO	2·90
Coaly Matter	4·6
CO ₂	32·1

It seems fairly certain that in the Garscube, Gartnavel and Jordanhill fields the Upper Possil Ironstone is represented by a seam known as the Wee Coal. This coal generally has a rib of clayband above it, and sometimes one of blackband also. There is a close resemblance between the Wee Coal of Skaterigg Engine Pit

and the Upper Possil Blackband of Hamiltonhill (Lanark, 6 N.W.), as the following sections show:—

Skaterigg Engine Pit.			Hamiltonhill.		
Wee Coal.			Upper Possil Blackband.		
	Ft.	In.		Ft.	In.
CLAYBAND . . .	0	4	CLAYBAND . . .	0	3½
Strata (? blaes) . . .	0	4	Blaes . . .	0	9½
BLACKBAND . . .	0	4	PARROT . . .	0	2½
COAL . . .	1	8	BLACKBAND . . .	0	5
			COAL . . .	1	6

Apart from this resemblance the two seams occupy the same relative positions above the Main Coal, and lie $3\frac{1}{2}$ fms. below a coal which in the one field is known as the Upper Possil Coal, and in the other as the Davy Coal.

Blackbands of Blairdardie and Drumchapel.—The Wee and Davy coals of Garscube, etc., which we have just seen to correspond approximately to the Upper Possil Ironstone and Upper Possil Coal respectively, do not appear to be represented as workable coal seams at Blairdardie and Drumchapel. Near No. 4 Pit, Blairdardie, a 10-in. blackband was wrought over a small area about 1872–5. To the south, however, near No. 1 Pit, bores record on the same horizon:—

	Ft.	In.
IRONSTONE	0	3
Blaes	2 in. to 0	4
COAL	16 in. to 1	8

This horizon lies 16 fms. above the Main Coal. At Drumchapel No. 1 Pit, again, which lies a little to the north of Blairdardie No. 4, a 7 to $10\frac{1}{2}$ -in. blackband was found and worked at a height of about 17 fms. above the Main Coal, and in a bore a little north of Garseadden Mains (Dumbarton, 23 S.E.), the following is recorded at 16 fms. above the same seam:—

Blaes and clayband ribs		
BLACKBAND		7 in.

It would seem, then, as if the Wee Coal of Garscube, Knightswood, etc., which lies 15 or 16 fms. above the Main, is represented at Drumchapel and in the north part of the Blairdardie field by the thin blackbands mentioned above. To the table given on p. 85 may be added, therefore, the following tentative correlation:—

Upper Possil Ironstone = Wee Coal = Blackbands of Blairdardie and Drumchapel.

Batchie Ironstone of Cadder.—This is a local seam of blackband ironstone and parrot coal found in the Cadder district, and lying 1 or 2 fms. below the Upper Possil or Cadder Main Coal. It is an exceedingly variable seam. The limits within which it occurs as a workable subject are roughly bounded by a line joining Cadder, Balmore, Summerston, Caddereuilt, Westfield and Kenmore House. The area thus defined has a north-east to south-west extension of about $3\frac{1}{2}$ miles, and is perhaps $1\frac{1}{2}$ miles wide at its broadest part, but it is only in patches within this area that the blackband exists in workable thickness. An average section of the seam shows:—

PARROT COAL 9 to 18 in.
 BLACKBAND IS. 3 to 7 " "
 COAL 3 to 7 "

but the thicknesses given are liable to constant variation. Sometimes a little parrot occurs below the ironstone as well as above it. The Batchie has been wrought to some extent at No. 15 Pit, Cadder, by the Carron Company. At the old No. 5 Pit, Blackhill, about half a mile south-east of the present Blackhill Pits, the Summerlee Iron Company, about 1875, worked a small area of an ironstone known locally as the Upper Blackband or Wee Stone. This horizon appears to represent the Batchie ironstone of Cadder (see table on p. 92). At Gilslochhill Mine again, which lay just west of the Western Necropolis, the blackband worked as the Upper Possil Blackband appears to occupy the same, or approximately the same, stratigraphical position. The sections of the Blackhill Wee Stone and of the Gilslochhill Blackband were as follows:—

Wee Stone.	"Upper Possil B.B." of Gilslochhill				
	Ft.	In.	t.		
PARROT COAL .	1	6	WILD PARROT .	1	8
BLACKBAND IS.	0	7	BLACKBAND IS.	1 in. to 0	5
Daugh .	0	5	WILD PARROT .	0	3
			Daugh or Coal .	0 to 0	3

Beyond the limits of the area defined above the seam is not found developed as a blackband. The associated parrot coal persists to the north-east, and the horizon is represented in a bore on Carleston by a 13-in. parrot coal. In the Possil and Springburn district the horizon is represented by a coal which lies a few feet below the Upper Possil Coal. In the Garscube-Knightswood area the equivalent horizon cannot be satisfactorily determined.

(2) *South of the Clyde*.—The Possil subgroup to the south of the Clyde is poor in ironstones, and only one or two horizons call for mention (see Section 1, Fig. 9).

Pollokshaws Lower Ironstone and Coal.—This seam was wrought partly for its ironstone in an old pit just west of the Glasgow and Kilmarnock Joint Railway, a little to the north of Pollokshaws (Renfrew, 13 N.W.). No details regarding it are available, but the ironstone was almost certainly a blackband. At Titwood Colliery 7 in. of ironstone directly overlay 15 in. of coal, but at Lochinch again the whole seam consisted of coal (17 in.). The section of this horizon in the Sheep-park bore is as follows:—

IRONSTONE, with sand	7 in.
Dark blaes	10 "
COAL	15 "

South of Pollokshaws we find the same seam in the Giffnock field, where it lies some 24 fms. below the coal at present worked at Giffnock Colliery. It shows here a workable thickness of coal, gas, coal and blackband, and although it has so far been proved in a few bores only, it is likely to be exploited in the future. The details of the seam, as recorded in a bore a little west of Orchard Farm, are as follows :-

		Ft.	In.
IRONSTONE	.	0	2
Black blaes	.	1	3
PARROT COAL	.	0	9
IRONSTONE	.	0	4
PARROT COAL	.	0	5
ROUGH COAL	.	0	6

It is even better developed in the neighbourhood of Giffnock Colliery, where a bore records:—

		Ft.	In.
GAS COAL	.	0	8
BLACKBAND	.	0	9
Blaes and IRONSTONE ribs	.	1	6
GAS COAL	.	0	11
BLACKBAND	.	0	9
IRONSTONE and GAS COAL ribs	.	0	7
Blaes and irony fakes	.	0	9
GAS COAL	.	0	4

Upper Ironstone or Upper Ironstone Coal.—A seam of this name was known at Cowglen (Renfrew, 13 S.W.), but there is no available information regarding its thickness and quality. For its position in the sequence see Fig. 9. The few bores that pass through its position record no ironstone of any value.

Ironstone associated with the *Main* and *Jewel Coals* at Giffnock Colliery.—The Jewel seam is the only coal in the Limestone Coal Group south of the Clyde that is at present wrought; up to the middle of 1915 the Main seam alone was mined, and the combined section is as follows:—

		Ft.	In.
MAIN SEAM	BLACKBAND	1 in. to	0 6
	Blaes	.	0 5
	COAL	.	0 5
	GAS COAL.	.	0 2
	COAL	.	0 10
	GAS COAL.	.	0 3
JEWEL SEAM	COAL	.	0 5
	Fireclay or blaes	3 to	5 0
	IRONSTONE balls	.	0 6
	WILD PARROT	.	0 6
	COAL	1 ft. 11 in. to	2 3
	Sandstone		

The rib of blackband above the Main Coal formerly yielded a small supply of ore; in 1914 the amount was 1775 tons, and when the workings in this seam come to be resumed a blackband output of approximately that magnitude may be expected. The clayband balls above the Jewel Coal sometimes form an almost continuous layer about 6 in. thick, and are at present worked along with the coal and parrot.

These two coals appear to correspond to the Rough and Stinking coals of the Cowglen district, and farther west are perhaps represented by the Barrhead Main. A few inches of blackband is locally recorded in association with these seams, just as at Giffnock.

Kirkintilloch, Kilsyth and Banton.

One-in. Geological Map, Sheet 31; 6-in. Sheets, Stirling, 28 N.E., S.E.; 29 N.W., S.W.; 33 N.W., N.E.

The belt of Carboniferous Limestone strata lying to the south of the volcanic rocks of the Kilsyth Hills, and forming the north-western edge of the Central Coalfield, was formerly one of the main centres of ironstone-mining in Scotland. Both blackbands and claybands were worked. The former were local and irregular seams occupying detached basins between which the ironstone was absent or very thin. The latter, confined to two horizons, were more persistent, but the increased cost of working such thin seams and the competition of high-grade imported ores have led to their abandonment. At present the only ironstone worked is that known as Kilsyth No. 3 Blackband, which is raised at Dumbreck Colliery. The positions of the various coals and ironstones are given in the table of comparative vertical sections in Fig. 10.

Garibaldi Claybands.—Claybands on this horizon have been wrought to some extent at Banton, at Nethercroy and at Auchinvole. The sections at Banton and Nethercroy were as follows:—

Banton.	Ft.	In.	Nethercroy.	Ft.	In.
Blaes	3	0	Blaes roof	.	.
Blaes	1	0	CLAYBAND	0	5
CLAYBAND	3 in. to 0	4	Blaes	2 in. to 0	6
Blaes	0	9	CLAYBAND	2 in. to 0	5
CLAYBAND	0	4	Blaes	1 ft. 8 in. to 2	6
Blaes pavement			CLAYBAND	5 in. to 0	8
			Blaes, brushed	2	0

(1) *Banton*.—In this field the Garibaldi Clayband horizon was known as the "Finestone." The Finestone was worked by the Carron Company as long ago as the end of the eighteenth century; in 1875 a small area south of No. 5 Pit was opened out. The seam lies here some 7 fms. below the Banton or No. 4 Blackband, and about 8 fms. above the Kilsyth Coking Coal.

(2) *Nethercroy*.—A few small areas of the Garibaldi Clayband were opened out by the Carron Company at Nethercroy about the years 1889–93. Here it lies 4 fms. below the Banton Blackband and 7 fms. above the Kilsyth Coking Coal.

(3) *Auchinvole No. 3 Pit*.—A very small area of the Garibaldi Clayband (7 in.) was wrought here.

The evidence available regarding this horizon shows that the area within which it is best developed extends as a narrow strip of ground from Banton through Kilsyth and Nethercroy to Gartshore. It is poorly represented at Meiklehill and Kirkintilloch and to the south and east of Nethercroy. West of Kilsyth also, at Dumbreck, etc., it is of little value. Within the area thus roughly defined it varies considerably, showing, where best developed, from 12 to 16 in. of clayband in a 4 to 5-ft. blaes working. There is frequently a little coal not far below the ironstone, just as in the Glasgow District (compare p. 69).

Kilsyth No. 4 or Banton Blackband.—The Banton Blackband lies about 12 to 14 fms. above the Kilsyth Coking Coal, taking the area

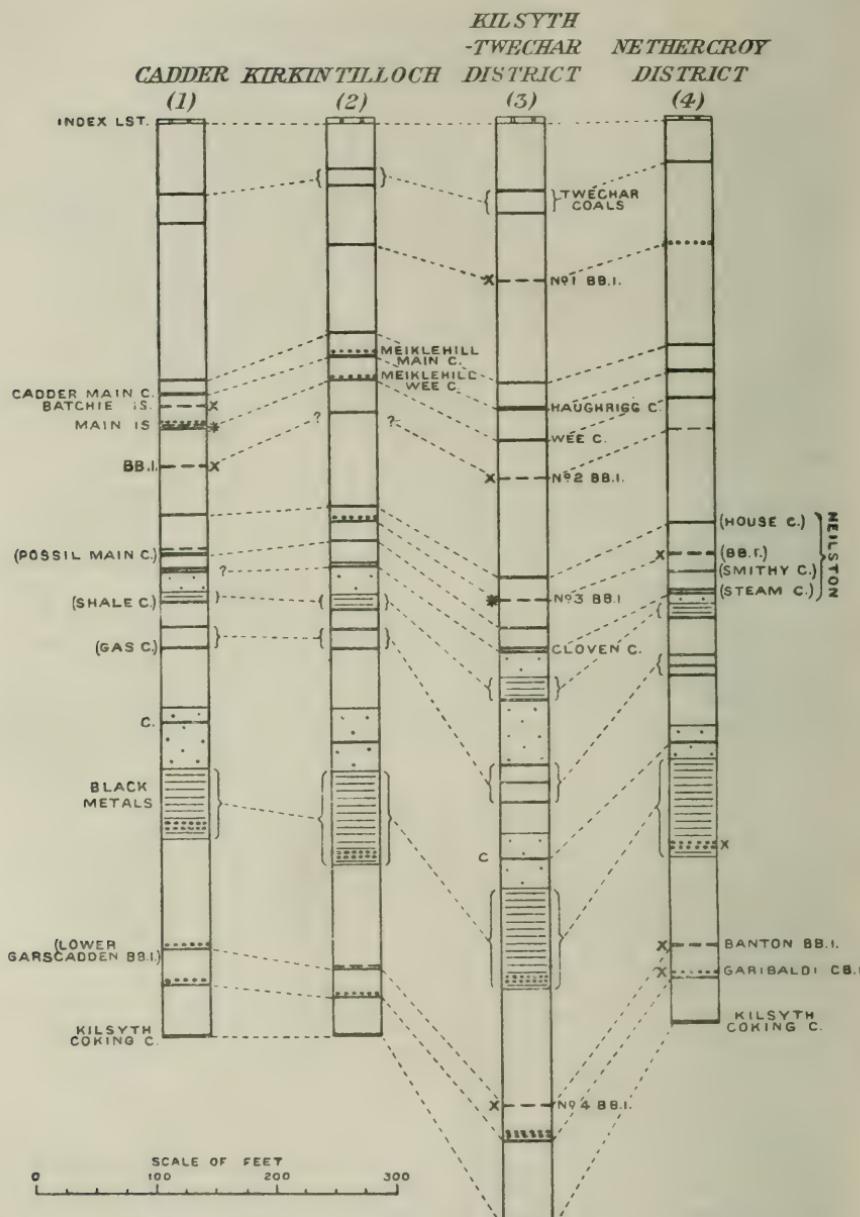


FIG. 10.—Comparative Vertical Sections of part of the Limestone Coal Group in the Kilsyth-Kirkintilloch District.

C. = Coal.

IS. = Ironstone.

BB. I. = Blackband Ironstone.

* Indicates seams at present worked.

CB. I. = Clayband Ironstone.

LST. = Limestone.

X Indicates seams formerly worked.

as a whole; but the distance increases locally to as much as 16, 18 or 22 fms. in the north-eastern part, and may be only 10 fms. in the south-western part, of the Kilsyth field. It lies 4 to 7 fms. above the Garibaldi Claybands, and some 15 to 18 fms. below the base of the Black Metals. It corresponds in position with the Lower Garscadden or Govan Blackband of Glasgow (see p. 77), but there is a large area around Springburn, Cadder and Kirkintilloch, where the horizon is very poorly developed. This barren area separates the two fields of N.W. Glasgow and of Kilsyth, in both of which the Banton Blackband exists, though locally, in workable thickness.

The area over which the Banton Blackband shows a thickness of 7 in. and upwards extends from Banton south-westwards nearly to Gartshore House, and from Kilsyth to Nethercroy in a south-easterly direction. The best patches of ironstone within this area have been worked out. It was formerly raised at Banton, Barrwood (Kilsyth), Nethercroy, Auchinvole and Gartshore.

(1) *Banton*.—Here the seam occurred in a shallow syncline on the lands of Banton and Tamrawer, and was worked to the outcrop. The syncline opened to the north, but was truncated abruptly by a powerful upthrow fault. The depth of the seam at the centre of this basin was about 43 fms., and the working section shown on the old plan of the field was:—

	Ft.	In.
Blaes	2	0
MAGGIE *	0	1½
BLACKBAND	0	9
Coarse fireclay	2	6

Thicknesses of 14 and 15 in. are recorded, and the seam was worked locally when as thin as 4 or 5 in. The working faces bear dates between 1852 and 1885.

(2) *Barrwood*.—At Barrwood No. 2 Pit, Kilsyth, the section was similar to that at Banton, and the ironstone varied from 8 to 21 in. It was here 132 fms. deep.

(3) *Nethercroy*.—The Banton Blackband has been worked over a considerable area at Nethercroy, just south of the Forth and Clyde Canal. The section recorded in the plan of the abandoned workings of No. 1 Pit (Blackband at 69 fms.) is as follows:—

	Ft.	In.
Blaes roof		
Blaes, brushing	2	6
Limy rib	0	2
BLACKBAND	8 in. to 1	2
COAL	0	2
Fireclay holing	6 in. to 1	3
Sandstone pavement		

It was an irregular seam showing areas of "thin stone," and on the eastern and southern edges of the workings deteriorated in thickness to as little as 3 in. East of Nethercroy, at Croyhill and Auchinvole, and again to the south-east at Croymill, it is very variable and generally poor. This seam was worked at Nethercroy by the Carron Company as late as 1914, the date of the abandonment of the colliery there.

* *I.e.* poor or inferior. See Glossary, p. vi.

(4) *Auchinvole*.—The same ironstone has been worked to some extent at Strone, west of Nethercroy and south of Kilsyth, where the seam comes close to the surface along the anticlinal axis known as the "Rigging." The section here showed :—

	Ft. In.
Blaes roof	
Blaes, brushed	1 4
BLACKBAND	5 in. to 0 8
Fireclay	1 in. to 0 2

The Strone blackband was known as early as 1839, and the first workings in it were probably begun soon after that date.

About 1883 a little blackband was taken out beneath the Forth and Clyde Canal at Strone, but the bulk of the workings are of a much older date.

(5) *Gartshore*.—The seam occurs in workable thickness in parts of this field. It varies from 0 to 24 in., and has typically a roof and pavement of fireclay.

Within the area of Banton Blackband as defined above, there probably exist other patches of workable thickness besides those mentioned. One of these lies south of the Banton Basin, between Low Banton and Townhead, where the ironstone seems to average 8 or 9 in. and to vary from 5 to 14 in. With such irregular and patchy blackbands as these of the Kilsyth district, however, it is not possible to say where they are workable without much fuller information than is available. Any reserve likely to be exploited in the future can only be small. As for the districts outside the limits given the Banton Blackband is poorly represented. West and south-west of Kilsyth it appears as one or two thin ironstone ribs over a few inches of coal, and the section at Meiklehill, Wester Gartshore, Kirkintilloch and Cadder is much the same. To the south-east again towards Dullatur and Cumbernauld it appears to have no economic value. An analysis will be found on p. 96.

Banton Claybands.—The term "Banton Claybands" is applied to several bands or nodular layers of clayband ironstone which have been found in workable thickness in the lower part of the Black Metals of the Kilsyth district. In the Banton area these ironstones were wrought by the Carron Company soon after its inception in 1759-60 * and are among the very earliest Carboniferous ores to be used in iron-smelting in Scotland. Of these old workings little is known, but it is recorded that the seams varied from 4 to 18 in. in thickness.† Of much later date are the following workings :—

	Ft. In.
No. 1 CLAYBAND	0 3
Blaes	0 6
No. 2 CLAYBAND	7 in. or 0 8
Blaes	5 0
No. 3 CLAYBAND }	0 6
No. 4 CLAYBAND }	8 0
No. 5 CLAYBAND	1 2
Parting	0 1

* See p. 7.

† "Statistical Account of Scotland," vol. xviii., 1796, p. 231. "New Statistical Account," vol. viii., 1845, p. 144.

	Ft.	In.
No. 6 CLAYBAND	4	in. to 0 5
Blaes	3	0
No. 7 CLAYBAND	8	in. to 0 9
Blaes	7	0
No. 8 CLAYBAND	0	2
Blaes	2	0
No. 9 CLAYBAND	1	1
Blaes		

Nos. 2, 7 and 9 claybands were last worked about the years 1880-5 and very little workable ore is left in the Banton basin.

From No. 3 Pit, Nethercroy, the Carron Company worked a considerable area of Banton Clayband. The section here was:—

	Ft.	In.
Blaes		
CLAYBAND	0	3
Blaes	0	3
CLAYBAND	0	6
Blaes	0	3½
CLAYBAND	0	2½
Blaes	3	10
CLAYBAND (in roads)	0	5
Blaes		

The Black Metals with their associated clayband ribs are very persistent and form a readily recognisable horizon. There is generally near their base one band of ironstone, 9 to 11 in. thick, with thinner ribs a few feet above or below it. The claybands referred to have been proved in many bores over a wide area, and certainly contain a large reserve of ore. All available boring evidence has been carefully tabulated, with the result that over most of the Kilsyth-Kirkintilloch district an average of 14 or 15 in. of clayband might be expected in a 4 to 5 ft. blaes working. This takes no account of the other and thinner ribs which occur throughout the Black Metals. The area over which these claybands have been proved in borings is approximately 14,640 acres, and there is an area of nearly half as much again about which we know little or nothing. With an average of 15 in. over 14,640 acres we get a possible maximum total of nearly 66½ million tons of ore. This, of course, is a theoretical figure, and would never be attained on actual mining, but it gives a rough indication of the clayband available at one horizon in the Black Metals of a particular district. It may be added that a working of this nature belongs to the past, and would scarcely be attempted under present conditions. The Johnstone Clayband, for example, at present worked at Nitshill, shows about 20 in. of clayband in a 4 to 5-ft. blaes working.

The following analyses of the Banton Blackband and of one of the claybands from Low Banton were made in the laboratory of Messrs. D. Colville & Sons, Dalziel Steel Works, Motherwell, in April 1917:—

	1.		2.	
	Raw.	Calcined.	Raw.	Calcined.
Iron	Per cent.	Per cent.	Per cent.	Per cent.
Iron	40·96	61·95	34·75	48·78
Silica	0·56	0·85	8·26	11·63
Alumina	0·11	0·17	4·78	6·73
Lime	2·75	4·17	3·75	5·28
Manganese oxide	1·15	1·74	1·23	1·73
Magnesia	3·45	5·23	3·74	5·26
Titanium oxide	tr.	tr.	tr.	tr.
Phosphorus	0·28	0·42	0·42	0·59
Sulphur	0·062	0·094	0·014	0·02
Moisture	0·09	...	0·42	...
Loss on calcination	33·91	...	28·53	...

1. Banton Blackband, from Low Banton.

2. Banton Clayband, from Low Banton.

Kilsyth No. 3 or Neilston Blackband.—This blackband lies at Kilsyth about four fms. below the Neilston House Coal, the distance being rather less in the Twechar, Nethercroy and Gartshore fields. From the Haughrigg or Meiklehill Main Coal to the Neilston Blackband the distance is about 24½ fms. at Dumbreck and Twechar, and about 21 fms. at Nethercroy and Solsgirth. The ironstone has been wrought on a considerable scale at Neilston, Nethercroy, Gartshore, Twechar and Solsgirth; and is still raised at Dumbreck.

(1) *Neilston.*—The blackband was wrought here at least as early as 1859 up to about 1878. A small area was opened out again about 1885. A section of the seam as developed at Neilston has been recorded as follows:—

	Ft.	In.
FOUL PARROT COAL	1	7
BLACKBAND	1	1
BLIND COAL	0	5

(2) *Gartshore.*—A very considerable area of this blackband has been worked in the Gartshore field. At No. 9 Pit, where it was raised during the period 1876–90, it showed:—

	Ft.	In.
Fakes roof		
Fakes, brushing	1	0
WILD COAL	0	2
BLACKBAND	0	6
WILD PARROT	3	8
WILD COAL	0	3
Sandstone pavement		

At No. 7 Pit, Gartshore, the seam lay 27 fms. below the Haughrigg Coal, which is the maximum recorded distance between these horizons.

(3) *Twechar.*—At Twechar No. 2 Pit, in the workings of which the faces bear the dates 1880–6, the seam showed:—

	Ft.	In.
Fakes	2	6
COAL	0	2
BLACKBAND	0	11
SHALE	2	0
BALL IRONSTONE	0	3
COAL	0	6
Sandstone pavement		

(4) *Solsgirth*.—At the old Solsgirth pits (Stirling, 33 N.E.) the seam showed :—

	Ft.	In.
Black blaes		
BLACKBAND	0	5
Fireclay	3	0
WILD PARROT	1	3
BLIND COAL	0	3
Sandstone pavement		

The Neilston Blackband was locally known as the Gartshore Upper Ironstone to distinguish it from the underlying Banton or No. 4 Blackband. At Twechar (and also apparently at No. 9 Pit, Gartshore) it was termed the Lower Blackband in contradistinction to the Upper Blackband, also wrought at Twechar and now known as Kilsyth No. 1 Blackband.

(5) *Dumbreck*.—The only ironstone now raised from the Kilsyth field is the No. 3 Blackband of Dumbreck Colliery. The seam lies here 17 fms. below No. 2 Blackband and 24 fms. below the Haughrigg coal. It shows approximately :—

	Ft.	In.
Sandstone roof		
Dark fakes, brushing	1	6
COAL	0	2
BLACKBAND	1	2
SHALE	1	10
BALL IRONSTONE	0	6
COAL	0	6
Sandstone pavement		

The following is an analysis* of the No. 3 Blackband of Dumbreck Colliery :—

Raw Stone.	Per cent.	Calcined Stone.	Per cent.
Iron carbonate	70·00	Iron protoxide	3·60
Iron sulphide	0·65	Iron peroxide	75·20
Manganese oxide	0·60	Manganese oxide	1·20
Calcium carbonate	4·10	Lime	3·80
Magnesium carbonate	0·46	Magnesia	0·70
Clay (silicate of alumina)	8·04	Clay (silicates)	13·00
Phosphoric acid	1·02	Phosphoric acid	1·70
Bituminous matter	14·95	Sulphuric acid	0·90
	<hr/> 99·82		<hr/> 100·10
Metallic iron	34·10	Metallic iron	55·45

Kilsyth No. 2 Blackband.—This seam, known also as the *Haugh Blackband* from the fact of its being formerly wrought at Haugh No. 2 Pit, is a purely local seam at Kilsyth. It seems to have been

* See Brand, "Calcination of Blackband Ironstone at Dumbreck," *Trans. Instit. Min. Eng.*, 1903, vol. xxv., p. 256.

about 8 to 12 in. thick, and to have lain 8 or 10 fms. under the Haughrigg coal. Only a few acres were worked, and the seam elsewhere is of no value.

The Riskend mineral field (Stirling, 29 N.W.) contains a blackband ironstone lying $8\frac{1}{2}$ fms. above the Neilston Blackband, and known locally as No. 2. It was worked to some extent there, and showed approximately:—

	Ft.	In.
PARROT COAL	0	2
BLACKBAND	0	$11\frac{1}{2}$
BLIND COAL and coaly blaes	0	$9\frac{1}{2}$

If the relative positions of the ironstones at Riskend are correctly given, this seam lies some way below the position of the No. 2 Blackband of Kilsyth, and is of local occurrence only.

Kilsyth No. 1 Blackband.—This also is a very local seam of no economic value nowadays. It was wrought about 1883–6 at Twechar No. 2 Pit, over a small area, where the section showed:—

	Ft.	In.
Fakes and blaes	about	2
IRONSTONE (candy)	0	2
IRONSTONE	0	11
SHALE	1	5
Faky shale	0	8
COAL	0	6
Sandstone		

There it lay some 44 fms. above the Neilston Blackband, and about 19 above the Haughrigg Coal.

A blackband on the same horizon was formerly wrought at Riskend, but little is known about its thickness. The section recorded at No. 2 Pit, Riskend, is:—

BLACKBAND, $5\frac{1}{2}$ in.
COAL, 4 in.

Denny and Plean.

One-in. Geological Map, Sheets 31 and 39; 6-in. Sheets, Stirling, 23 N.E., S.E.; 24 N.W., S.W.; 29 N.E.

An account of the economic geology of this district will be found in the recently published volume on Area II. in the series of memoirs entitled "Economic Geology of the Central Coalfield." The Limestone Coal Group here is poor in workable ironstones when contrasted with the Kilsyth or Glasgow districts. The only ironstones of economic value nowadays lie near the base of the Black Metals. The Garibaldi Ironstones are here represented by one or two thin clayband ribs closely overlying a foul coal or coaly blaes, while the Banton Blackband is nowhere developed as a workable subject. As regards the Possil Subgroup it contains, in addition to several important coal seams, only two blackband ironstones, both very local and now exhausted. It has not yet been possible to definitely correlate these coals and blackbands with their equivalents in the Kilsyth sequence.

Banton Claybands.—The Black Metals of the Denny field average 8 or 9 fms. in thickness, and locally reach as much as 12 fms. The

associated ribs of clayband ironstone are specially abundant in the lower part of the series, just as at Kilsyth (Banton Claybands) or at Glasgow (California Claybands). One ironstone horizon near the base calls for particular notice. As proved in a number of bores over an area of more than a mile in extent lying to the south-west of Denny (Stirling, 23 S.E.; 29 N.E.), it consists of two or three clayband ribs which together yield a thickness of 18 in. of ironstone in 4 to 6 ft. of blaes. There is characteristically one band, 10 to 14 in. thick, at this horizon, with other thinner ones not far above and below. This band has also been recorded as thick as 20, 25, or even 30 in.; but these cases must be exceptional. There are old crop workings in some of the Black Metal claybands along the Castle-rankine Burn, just west of the area proved by the bores referred to, and some of these workings appear to be as old as 1768.* The ironstones wrought are said to have varied from 2 to 6 in. only, but we do know the actual horizon in the Black Metals at which they occurred, and they may possibly represent a higher part of that series than the ironstones described above.

To the north and east of Denny the same claybands must cover a very wide extent of country. They have not often been reached in bores; but where they have been proved there is typically one horizon near the base which shows one clayband 10 to 14 in. in thickness associated with thinner ribs above and below. Two sections of this horizon may be given by way of illustration.

Bore in No. 4 Pit, Plean.

(Stirling, 24 N.W.).

	Ft.	In.
IRONSTONE	0	3
Blaes	2	5
IRONSTONE	1	0
Blaes	0	3
IRONSTONE	0	2

Bore at Carbrook Mains.

(Stirling, 24 N.W.).

	Ft.	In.
IRONSTONE	1	4
Blaes	1	8
IRONY RIB	0	6
Blaes	0	8
IRONSTONE	0	8

Sometimes the thickest of the claybands at this horizon is described as limy, and farther north, towards Greenyards and Bannockburn, its calcareous character becomes strongly marked. It may be mentioned here that a useful index to this clayband horizon is furnished by a bed of shelly marine blaes, which is found in the Black Metals not far above it.

To sum up, it may be said that between the outcrop of the Black Metals on Drumbowie, Castlerankine and Quarter (Stirling, 29 N.E.; 23 S.E., N.E.), and the Plean district to the east there is a large field where, from the evidence available, a workable ironstone horizon appears to exist near the base of that series. From 16 to 20 in. of clayband of a somewhat calcareous nature occur in 4 to 5 ft. of blaes, and one of the ironstone ribs averages, perhaps, as much as 12 in. This horizon is met with at constantly increasing depths eastwards, but the shallower parts of the field along the line of outcrop might be worth attention.

The above remarks refer merely to areas where these claybands have actually been proved. In addition there exists a large area of Millstone Grit and Coal Measure strata to the east of Denny and Plean, where nothing is directly known of the development of the

* See p. 7.

Limestone Coal Group. The Banton claybands would, however, be at great depths here.

The following figures are added in order to give some idea of the extent of this clayband horizon:—

District.	Average Thickness.	Area.	Reserves in Tons.	
			Possible.	Probable.
Castlerankine (S.W. of Denny).	18 in. of clayband in a 4 to 5 ft. blaes working.	Approximately 900 acres.	4,860,000	...
N.E. and E. of Denny.	About 16 in. of clay- band in a similar working.	Area of which any- thing is known, say 24 sq. miles.	...	73 $\frac{3}{4}$ million.

The *Lower Twenty-inch Coal* of Plean has a variable rib of clayband in the blaes above it. This rib, where found, is wrought along with the coal.

Denny Upper and Lower Blackband Ironstones.—Two blackband ironstones have been wrought in the past in the Denny district (Stirling, 23 S.E.). Both were lenticular and impersistent. The lower one was raised to the south of the River Carron at Blaeaulds Colliery and at Herbertshire No. 1 Pit; the upper was raised in the area from Dunipace to Quarter, while both were worked in the old pits of Messrs. Baird at Tygetshaugh. That is, the Upper Blackband extended farther north from Tygetshaugh than the Lower Blackband as a workable subject, but when followed southwards the conditions were reversed. At No. 4 Pit, Tygetshaugh, the ironstones were approximately 8½ fms. apart, and showed the following sections:—

UPPER BLACKBAND.—Fakes and blaes				
WILD COAL	13 to 15 in.			
BLACKBAND	2 to 9 in.			
COAL	1½ in.			
LOWER BLACKBAND.—Fakes and blaes	4 ft. 5 in.			
Fireclay and balls	15 in.			
BLACKBAND	5 to 9 in.			

The Lower Blackband has been wrought also, as already stated, in the Herbertshire and Blaeaulds fields; it lies about 34 fms. under the Index Limestone on an average, the distance varying from 32 to as much as 38 fms. It is a variable seam thinning around the edges of the worked area to a few inches. Its average section as shown in bores was:—

PARROT	2 to 4 in.
BLACKBAND	6 to 16 in.
PARROT	2 to 11 in.

As a rule the lower parrot varied inversely with the ironstone. The seam thins away to a few inches on Little Denny, but further south appears to be represented by a 12-in. coal.

The strata between the blackbands average 7 to 8 fms. in thickness, and consist mainly of faky sandstones. In the upper part one or two thin coals are found close below the Upper Blackband.

The Upper Blackband section at Tygetshaugh has already been given. It was raised in several pits (Risk Pit, Drinalier Pit, Broomhill Pit and Anchor Pit), and in the Ingliston Mine to the south of Low Quarter Mill. In the Quarter Colliery area it shows:—

COAL (generally a parrot)	.	.	8 to 10 in.
BLACKBAND	.	.	7 in.
COAL	.	.	1½ to 4 in.

North and south of this strip, however, it appears to be represented by a coal. Thus a mine was driven from the workings of the Lower Blackband of Herbertshire beneath the River Carron, and the Upper Ironstone opened out over a small area to the south of the Castle. It was found to be 9–10 in. thick, but of a more coaly nature than at Tygetshaugh. South of the Carron River it becomes a 9 to 13-in. coal. While it is known that these blackbands pass laterally into coals, it is not easy to say in adjoining fields which coals actually represent them. It seems probable, however, that the Upper Twenty-inch Coal of Plean lies at or near the horizon of the Lower Denny Blackband.

Bo'ness.

One-in. Geological Map, Sheets 31 and 32; 6-in. Sheets,
Linlithgow, 1 N.E., S.E.

The coalfield of Bo'ness (Borrowstouness) has been uninterruptedly worked for over 170 years. The Limestone Coal Group here contains eight workable coals and two horizons at which blackband ironstone is found. Interstratified with the sediments occur beds of contemporaneous volcanic rocks which render the correlation of individual seams with those of other areas a matter of extreme difficulty. For information regarding the geology of this field, reference may be made to the Geological Survey Memoir on the Edinburgh District (1910).

Lower Ironstone.—This seam lies a few feet above the Six-foot Coal. It is found in the eastern part of the coalfield, but westwards towards Kinneil is poor or absent. In the old "Red Coal Pit" to the south of Bo'ness, where the ironstone was at a depth of 200 ft., it showed: *—

	Ft. In.
Coarse ironstone "kennel" roof	1 2
Bituminous blaes	2 2
BROWN IRONSTONE	1 0
Fireclay with ironstone nodules	0 2
PARROT OR CANNEL COAL	0 9
BLACKBAND	0 3
Fireclay with ironstone nodules	0 10

The best part of the seam on Bonsyde, Kinneil and Grange (Linlithgow, 1 S.E. and N.E.) was exhausted before 1875. Farther west it was worked up to 1895 at Borrowstoun (Mingle Pit) and Newtown (Lothian's Pit). In the Mingle Pit workings the section showed:—

	Ft. In.
COAL	0 9
PARROT COAL	1 2
BLACKBAND	0 10

* H. M. Cadell, "The Carboniferous Limestone Coalfields of West Lothian," *Trans. Instit. Min. Eng.*, 1901, vol. xxii., p. 379.

The same seam was also worked under the sea opposite Bo'ness Harbour from the old Schoolyard Pit, where it showed:—

	Ft. In.
COAL	3 in. to 0 10
PARROT COAL	15 in. to 1 7
BLACKBAND	3 in. to 0 10

At Bridgeness, again, it was also wrought under the Firth, but the blackband thinned away to 2 or 3 in. as the workings extended beyond the foreshore. One of the latest sections there gave coal 1 ft., blaes 1 to 3 ft., parrot coal 14 in., blaes and ironstone nodules 14 in.

The richest part of the field therefore extended from Bonsyde northwards towards Bo'ness, and its breadth in an east-and-west direction was approximately 1½ miles. Westwards from Newton and Borrowstoun it thins away. In the Kinneil Colliery field, for example, it is represented by a 2 to 3-in. impure blackband and some thin ribs of rough coal. The only direction in which reserves are likely to exist is to the north of the old underseas workings.

Upper Ironstone.—This seam lies a few feet above the Seven-foot Coal. The section at the Snab Pit was:—

	Ft. In.
UPPER BLACKBAND { COAL	1 2
Stone rib	0 9
BLACKBAND	1 5
Blaes and white "marled stone"	4 10
7-FT. SEAM { COAL	2 0
Stone rib	0 4
COAL	2 6

The blackband was formerly worked from the Snab Pit as far south as 1000 yds. south-west of Newton Cross Roads. The ore was smelted at the old Kinneil Furnaces. This seam also deteriorates westwards, and it is unlikely that any very considerable reserve remains.

Six-foot Coal.—Above the Six-foot Coal at Bridgeness occurs an inconstant layer of clayband balls which is worked when met with.

Bathgate and Wilsontown.

The strip of Carboniferous Limestone rocks extending from Bathgate to Wilsontown along the eastern edge of the great Lanarkshire coal basin, contains only two (or at most three) ironstone horizons that need be mentioned. These areas follows:—

Wilsontown Gas Coal.—In the old Cleugh Pits at Wilsontown a thin blackband is recorded below the Wilsontown Gas Coal. This seam lies 8 to 10 fms. below the Black Metals there and showed at Cleugh:—

	Ft. In.
GAS COAL	9 in. to 1 8
BLACKBAND	2 in. to 0 5
Blaes	0 4
COAL	1 in. to 0 5

This occurrence of blackband is of interest from the fact that a similar rib is found below the Main Gas Coal of Lesmahagow on the same horizon (see p. 104).

Hoggy Fence Ironstones.—This is an old name for the claybands found in the Black Metals of the Wilsontown district. They were

wrought here to some extent in the early days of the Wilsontown Ironworks, and their outcrop in the Mouse Water between Rootpark and Cleugh House (Lanark, 20 N.W.) is now marked only by the long abandoned mines. The ironstones wrought seem to have numbered four, and varied in thickness from 3 to 7 in.; they lay low down in the Black Metals and were taken out in one working. The section was approximately:—

	Ft.	In.
No. 1 OR "SPOTTED STONE" (shelly)*	about 0	3
Blaes	?	
No. 2 OR "BALL STONE" (nodular)	variable	
Blaes	2	0
No. 3 OR "BLACKBAND STONE"	a few in.	
Blaes	about 2	0
No. 4 OR "GREAT BANDS"	6 in. or 0	7

The same ironstones outcropped and were wrought in the Mossflat Burn near Harryfoothill (Lanark, 14 S.E.).

These representatives of the Banton Claybands have very little value in this district. The ribs are generally only 2 to 4 in. thick, seldom reaching 6 or 8 in. Very often the whole of the Black Metals (about 4 fms.) is recorded in bores merely as "blaes and balls." In the Bathgate field few bores reach this position, but all the evidence available shows it to be of no economic value, although the total amount of clayband ore must be considerable. A boring at Moss-side Colliery, for example, to the east of Durhamtown (Linlithgow, 9 S.W.), put down in 1903, recorded only a few ribs of 3 to 6 in.

Balbardie Blackband.—This blackband was found locally associated with the well-known Balbardie Gas Coal. As a workable subject, the Balbardie coal is of importance only in the northern part of this district between Balbardie (Linlithgow, 9 N.W.) and Stone-heap (Linlithgow, 12 N.W.). The ironstone was formerly worked along with the coal at Boghead, Moss-side and Hopetoun Collieries. Two sections may be recorded:—

Balbardie.	<i>Easton.</i>		
	Ft.	In.	
Blaes . . .	2	0	Sandy fireclay . . .
SOFT COAL . . .	0	5	WILD GAS COAL . . .
GAS COAL . . .	1	0	GAS COAL . . . 5 in. to 0
BLACKBAND . . .	0	3	BLACKBAND . . . 0
Fireclay . . .	2	0	Bally fireclay 13 in. to 1
FREE COAL . . .	1	7	FREE COAL 15 in. to 1
			10
			6

The blackband was a purely local constituent of the seam found between Balbardie and Moss-side. Only occasionally did it reach 6 in., while both to the west and south the gas coal and the ironstone thin away, the free coal alone persisting over a wide area.

Carlukie, Crossford and Auchenheathe.†

The Limestone Coal Group of this part of Lanarkshire is relatively poor in workable coals, and almost barren of workable ironstones.

* Probably the marine band referred to on p. 99.

† A full account of the geology of this district will be found in "Economic Geology of the Central Coalfield, Area IX.", to be published shortly.

The only horizons that fall to be mentioned are the Maggie Clay-bands of Carluke and the blackband ribs underlying both the Main and Wee Gas Coals. Thin as the latter were, they contributed, during the period 1857-63, 10,000 to 12,000 tons of ore to the Scottish iron industry.*

Blackband associated with Lesmahagow Main Gas Coal.—This coal was formerly extensively worked in the Crossford-Auchenheathe district, but is now entirely abandoned. It was locally associated with a thin blackband ironstone. South of the Nethan, near Crossford, it was raised in mines and shallow pits between its outcrop and the river gorge. The coal was here 18 to 20 in. thick, underlain by a blackband rib which reached as much as 9 in., but northwards both seams rapidly thinned away. To the north of the Nethan the same coal was worked up to 1884, but the portion of the seam developed as gas coal formed only a top ply, generally only a few inches thick. When of exceptional thickness—12 to 14 in.—it contained a rib of ironstone which had to be separated out.

At Auchenheathe, again, the Gas Coal was worked over a considerable area, where it averaged some 18 in. in thickness. A thin blackband of 4 or 5 in. underlay it in this field also, and seems to have been so rich in coaly material that clayband ore was added to it before calcination.

An analysis of the raw ironstone from Fence Pit ($2\frac{1}{2}$ in.) yielded FeO, 42·5 per cent.; CO₂, 29·50; SiO₂, 3·50; Al₂O₃, 2·98; CaO, 2·01; MnO, 1·21; MgO, 2·21; P₂O₅, 0·84; S, 0·51; FeS₂, 0·45; coaly matter, 13·78; water, 0·32 (total, 99·83).

Maggie Bands.—This is the local name for the nodular layers of clayband found in the Black Metals of the Carluke district. They are exposed in Jock's Gill (1) 500 yds. above Hallcraig and (2) above Crawfordwalls Bridge (Lanark, 19 S.W.). The ironstone ribs amount in all to about 16 in. of stone, but are said to be of inferior quality. The same horizon at Auchenheathe is only some 20 or 30 ft. thick, and was known in the old days as the "Long Tills." Here the clayband is in nodular layers, 3 to 6 in. thick, and numbering six or seven. Any workings in this horizon were merely outcrop samplings, save in the case of the very small area wrought at Fence Pit, where the section was:—

				In.
IRONSTONE	.	.	.	$2\frac{1}{2}$
Blaes	.	.	.	12
IRONSTONE	.	.	.	5
Blaes	.	.	.	36
IRONSTONE	.	.	.	$2\frac{1}{2}$

Wee or Upper Gas Coal.—This coal is developed only over a very limited area in the Auchenheathe-Blackwood field. It varied from 12 in. down to as little as 1 in., and had generally a 3 to 5-in. blackband rib immediately below it.

East Kilbride.

A detailed account of the geology of this district has been published as Area VIII. in the series of memoirs entitled "Economic

* See Greenshields, "Annals of Parish of Lesmahagow," 1864, pp. 244-53, and Appendix.

Geology of the Central Coalfield" (1917). The only ironstone horizons of any importance are the following:—

Earnockmuir Blackband.—Around Earnockmuir a seam of blackband ironstone was at one time wrought in several pits. It lies some 7 or 8 fms. below the base of the Black Metals on the same horizon as the Main Gas Coal of Lesmahagow (see p. 102) or Gas Coal of Wilsontown (see p. 102). This blackband belongs to the group of coals known in the East Kilbride district as the Crutherland Coals, and is a locally-developed blackband representing either the House or the Jaunt Coal of that group. It is found along the eastern margin of the East Kilbride basin. It was distinctly parrot in nature, calcining very readily, and passed laterally into a coal. The occurrence of this blackband is of interest from the fact that both at Lesmahagow and Wilsontown an ironstone of a similar nature is found upon the same horizon. There is not likely much of it left in the main basin of East Kilbride, but farther east, towards Meikle Earnock and Quarter, where there is an unproved area of the Crutherland coals, it may possibly recur.

It may be noted that the Crutherland seams are typically overlain by blaes containing clayband lenticles or balls. The Jaunt Coal, for example, where exposed on the east bank of the Calder, due south of Edge Farm, has a blaes roof with lenticles and balls of clayband 6 or 7 in. thick.

Earnockmuir Clayband.—This seam was also worked in the Earnockmuir Pits. It was about 9 in. thick, and lay 8 fms. above the Blackband near the base of the Black Metal series. The Black Metals are about 3 fms. thick at Earnockmuir, and consist as usual of blaes and ironstone balls with locally a nodular clayband rib near the base in the position of the California Claybands of Glasgow (p. 80) or of the Banton Claybands of Kilsyth (p. 94). As in many other districts, a marine horizon found not far above this clayband serves as a useful index in boring operations.

MILLSTONE GRIT.

The characteristic sediments of this division of the Scottish Carboniferous Rocks are fireclays and sandstones. Over by far the greater part of the Central Coalfield the only ironstones in the Millstone Grit Series consist of scattered clayband balls in the thick beds of blaes and fireclays that occur throughout it. At four horizons, nevertheless, seams of ironstone have been locally wrought to some extent. These are the Curdly Ironstone and the Ginstone in the Levenseat (Fauldhause) district, the Goodockhill Blackband or Lower Slatyband developed in the neighbourhood of Salisbury, and the Bowhousebog ironstone found only over a small area lying southwest of Shotts. They are all very impersistent deposits of little potential value under existing conditions.

Curdly Ironstone.—The Curdly or Curly Ironstone consists typically of a band of clayband nodules, of very variable thickness, occurring in a bed of fireclay. The very irregular shape and size of these nodules would seem to have given rise to the name by which the bed is known. This horizon lies 9 or 10 fms. above the Levenseat Limestone, and at many points along its outcrop between Breich

Station (Edinburgh, 10 N.E.) and the Darmead Linn (Lanark, 13 N.E.) it was worked from mines and shallow pits. Some of the crop workings are very old, and probably go as far back as the early years of the nineteenth century. Of the workings near Breich Station and at West Handaxwood we know little, but the ore is said to have been of excellent quality. A mine was driven about the year 1870 from the right bank of the Breich Water, a little above Breich Bridge, presumably to catch the seam to the dip of the old workings, but, although it reached a bed of "Curdly ball ironstone," the workings only continued a few months.

From the east-and-west fault at Bankhead southwards to the Gladsmuir Hills the outcrop is marked by a litter of old refuse heaps. Ore was wrought here for the long-abandoned ironworks at Wilson-town (ceased 1842), for the Shotts Iron Co., and for Messrs. Wm. Dixon & Co. The workings of the last-mentioned company did not stop until 1901, and the section of the seam, as recorded on the working plan of that date, showed:—

	Ft. In.
Fireclay with balls	1 0
Black blaes	0 5
CURDLY IRONSTONE	4 in. to 0 8
Black blaes	0 6
Block (<i>i.e.</i> limestone)	0 9
Fireclay	

An earlier section (1873) taken in the same field showed:—

Fireclay				
Fireclay and IRONSTONE balls				5 ft.
Fireclay				

Characteristically the Curdly Ironstone is underlain by a 10-in. shelly limestone rib which enables its position to be identified in bores.

A small area of the seam was also wrought just east of Darmead Linn, where the main clayband was a 4 to 14 in. nodular rib. "Wants" were met with in the workings, and adjoining bores showed that the seam was very inconstant.

The horizon is not likely to attract any attention in the meantime, although little is known of the development of the ironstone beyond the actual limits of the old workings. Any evidence we possess on this point, however, proves it a very variable seam, and probably workable only in patches where comparatively shallow.

An analysis of the charred stone from Handaxwood has been kindly furnished by Messrs. Wm. Dixon & Co. Ltd. It shows:—

	As Received.	Dried.
	Per cent.	Per cent.
Iron (metallic)	46·74	47·60
Insoluble	19·05	19·40
Lime	2·30	2·35
Magnesia	1·76	1·80
Sulphur	0·74	0·76
Water	1·79	

Some of the ironstone balls obtained in the old workings are said to have weighed nearly a hundredweight.

A small area of the Curdly Ironstone was wrought about 1872 at Davisdykes, on the Auchter Water, some two miles east of Newmains (1-in. Geological Map, Sheet 23; 6-in. Lanark, 13 S.W.). The seam lay 9 to 11 fms. deep and showed:—

		Fms.	Ft.	In.
Sandstone	.	5	0	0
CURLY IRONSTONE	.	0	1	6
COARSE IMPURE IRONSTONE	.	0	0	9
Limestone	.	0	2	2
Blaes	:	0	0	6
Coal	:	0	0	2

The ironstone was nodular in character but of good quality. It seems to have soon thinned away, however, and neighbouring bores do not record it in workable thickness.

In the anticline of Millstone Grit rocks which runs north-north-westwards towards Salsburgh, the Curdly Ironstone is again found locally at shallow depths. Here and there bores record it as a workable subject. In the south part of Big Wood (Lanark, 13 S.W.), for example, there is a small area where 6 bores each about 26 fms. deep record variations from 0 up to 3 ft. 1 in. with an average of 14 in. It is apparently too inconstant a seam, however, to merit serious exploitation, although small patches might still be found workable where the seam is shallow.

It might be added that the limestone underlying the Curdly in the localities mentioned above corresponds to the shelly Cement Limestone of the Castlecary, Cumbernauld and adjoining districts, where a somewhat calcareous ironstone is locally developed in this position.

Ginstone.—This was the name given to a bed of fireclay containing ironstone balls formerly wrought for the Wilsontown Ironworks in several shallow pits on the south side of the Breich Water, near Fauldhouse. These balls are said to have contained a high percentage of iron. An old section of this horizon records:—

		Fms.	Ft.	In.
Sandstone	.	2	0	8
Fakes	.	0	0	8
Blaes with 2 IRONSTONE ribs (4 and 5½ in.)	.	0	3	11½
Sandstone				

It lies about 24 fms. under the Crofthead Slatyband Ironstone.* The seam was known also as "Thomson's Balls," and at one or two other localities attempts on a small scale were made to work a thin ironstone on what is probably the same horizon. There are records of shallow pits at Brow and Bucht, on the north side of the Auchter Water (Lanark, 19 N.W.), and again a little north-east of Redmire Loch (Lanark, 13 S.W.), which appear to have been sunk to this position, but apparently very little was done. The position of the Ginstone cannot be readily identified in bores; in any case it has long ceased to attract attention.

Goodlockhill Slatyband (Lower Slatyband of Earlshill and Dunellan).—This seam lies in the upper part of the Millstone Grit Series (see Fig. 11). It is locally developed in the Kirk of Shotts-

* Or base of Coal Measures. See p. 110.

Salsburgh district. The area within which it occurs as a workable subject may be roughly defined as extending from Goodockhill and South Shottsmyre, north-north-westwards to Lochhill and Earlshill. The ironstone is not of uniform thickness throughout this area however; it is very variable and occurs in a number of more or less isolated deposition basins, between which it thins away to a few inches, or may be absent altogether.

(1) *Goodockhill*.—The old workings here lie a little way north-east of Goodockhill Farm, between two north-north-westerly running faults about $1\frac{1}{2}$ miles apart (Lanark, 12 N.E.). These faults mark the limits of the workings, which in other directions seem to have been discontinued on account of the thinning away of the seam. Grossart, writing in 1868* says:—"The ironstone at Goodockhill has been wrought at 6, 4 and 2 ft. thick, thinning out to a few inches, and again swelling out to its usual thickness." North of these workings, again, and west of Salsburgh the Goodockhill is apparently represented by a sulphur coal, associated with ironstone "reeds," but appears again at Drumbowie as a workable subject (see below). To the south-east, again, there is no evidence that it has any economic value as an iron ore; in bores around Jersey it is very poorly represented.

(2) *Shottsmyre* (Lanark, 9 S.W.).—Here a considerable area of the Goodockhill Ironstone was wrought between Merchanthall and Roundknowe to the south-west of Kirk of Shotts. It varied here from 6 in. to 2 ft. 7 in., and when last worked by the Shotts Iron Co., about 1876, averaged some 13 in. One bore records a 4 ft. 5 in. blackband at this horizon. To the south of Shottsmyre, again, and all round the edge of the Shotts-Fauldhouse basin its position, so far as is known, is represented by a bed of blaes with thin ironstone ribs or "reeds" overlying a foul coal. The seam at Shottsmyre lies some 27 fms. below the Crofthead (or Duntillan Parrot-top) Coal, and this distance increases eastwards to 32 fms. In one or two instances only is a workable ironstone recorded. Thus on Fauldheads Farm, at West Benhar (Lanark, 9 S.E.), a bore records a 4 ft. 3 in. ironstone in this position, and again on Headlesscross (Lanark, 13 S.E.), $1\frac{1}{2}$ miles south-west of Fauldhouse Station, it is given as a 3 ft. 2 in. ironstone. These instances appear to be quite exceptional however.

(3) *Duntillan, Drumbowie and Earlshill* (Lanark, 8 S.E., N.E.).—A considerable area of this seam has been worked to the north-north-west of Salsburgh, where the ironstone was apparently known to occur as long ago as 1839.†

It occurs here over a narrow belt of ground extending through Drumbowie to Lochhill and Earlshill. Some of the workings are very old, and practically nothing is known of them. The Summerlee Iron Co. worked the seam about 1862 from their No. 1 Dunsyston Pit, where it was 47 fms. deep. The Duntillan workings of the Coltness Iron Co. were abandoned about 1883 (Duntillan No. 1, Drumbowie and Mountcow Pits). The recorded section of the seam here shows:—

* *Trans. Geol. Soc. Glasgow*, vol. iii., 1868, p. 107.

† See Craig, "On the Carboniferous Formation of the Lower Ward of Lanarkshire," *Trans. Highland and Agric. Soc.*, Second Series, vol. vi., 1839, p. 348.

	Ft.	In.
Sandstone roof		
Blaes	0 to	5 0
IRONSTONE	3 in. to	6 0
COAL	0	1
Sandstone pavement		

In the middle of the worked area a large "want" was proved, and on the margins the seam thinned away quickly. Further north again small patches of this ironstone were worked at Lochhill and Earlshill. The latter place appears to be the only place where both the Goodockhill and the Upper Slatyband were worked (see p. 112), and here the Goodockhill was known as the Lower Slatyband. At Lochhill the section was:—

	Ft. In.
Sandstone roof	
Blaes	4 0
IRONSTONE	4 in. to 4 6
PYRITES	0 4
COAL	0 8

It varied very much, however, and the maximum thickness of the section given above merely represents a pocket.

At Salsburgh the position of the Goodockhill seam is represented by a foul coal sometimes with thin ironstone ribs above it.

In no other area has a workable ironstone been recorded at this horizon.

Bowhousebog Ironstone.—This is a very local seam of blackband ironstone, which lies 2 or 3 fms. under the Bowhousebog Coal in the New Mill district, about half a mile to the south of Hartwood Station (Lanark, 13 S.W.). It was a very irregular seam, wrought only on a small scale in shallow pits near New Mill, where it appears to reach a thickness of 2 ft. It was repeatedly passed through in bores, but as a workable subject is confined to the Bowhousebog, Ladylands and Hartwood district. At Bowhousebog it varies from 2 in. to 2 ft. 9 in. On Ladylands bores record variations from 4 in. up to 2 ft. 2 in. It is purely local in its occurrence, and has been found nowhere else in the Central Coalfield.

There is an area lying a little to the west of New Mill where the Bowhousebog Ironstone is at a shallow depth and where it has been proved by a number of bores. There the seam varies from 0 up to 3½ ft., but the average thickness is only about 10 or 11 in. The evidence of the bores here shows that the seam varies very rapidly in a lateral direction, and consists of lenticular patches of ironstone.

COAL MEASURES.

The Coal Measures of the Central Coalfield contain both blackbands and claybands, but the series as a whole, compared with the underlying Limestone Coal Group, is poor in workable ironstones. The famous Airdrie and Palacecraig Blackbands have long been exhausted, and the only ironstones at present worked are the lenticular ribs of clayband, or the layers of clayband nodules, found in association with workable coals. These claybands occur mainly in the brushing of the lower coal seams of the Coal Measures along the eastern edge

of the Central Coalfield, in the Falkirk, Armadale and Fauldhouse districts. The most important is the Ball Ironstone which immediately or closely overlies the Armadale Ball Coal. In Fig. II. the chief horizons in the Coal Measures and the relative positions of the ironstones that have been, or are being, worked, are shown in graphic form.

Crofthead Slatyband Ironstone.—This horizon has been adopted, wherever it can be recognised throughout the Central Coalfield, as the base of the Coal Measures. It is only locally developed as a blackband, and over considerable areas is represented by a pyritous coal. In many districts indeed its exact position is only approximately known. This local character of the seam has led to its passing under a number of different names, according to the mining field in which it occurs as a workable subject. It was first found in the neighbourhood of Fauldhouse, and reaches here its widest development as a workable blackband. The following ironstones are upon the same, or approximately the same, horizon as the Slatyband of Fauldhouse and Crofthead.

Upper Slatyband of Earlshill.*

Slatyband of Moffat Hills, Arden, Stanrigg, etc.

Slatyband of Auldshields (Greengairs).

Slatyband of Garbethill, Loanfoot and Roughcastle.

Crookedstone Slatyband of Quarter (Hamilton).

Lower Slatyband of Birkenshaw (Larkhall).

(1) *Slatyband of Crofthead, Fauldhouse, Benhar and Harthill*.—(Six-inch Sheets, Linlithgow, 11 S.E., N.E.; 12 S.W. Lanark, 9 S.E.) The area over which the *Crofthead Slatyband* has been worked in this district stretches from the outcrop of the seam at Crofthead and Greenburgh north-westwards to Harthill village, a distance of 4 miles. It is roughly of the shape of an hour-glass, being narrowest near East Benhar and widening out to N.W. and S.E. The width of the workable area at Fauldhouse was about $1\frac{1}{2}$ miles and at Harthill approximately $1\frac{1}{4}$ miles. The seam was wrought by Messrs. Wm. Dixon & Co. Ltd. from Nos. 8 and 9 Pits, Fauldhouse, and later from No. 13 Pit up to the year 1891. Farther north it was raised between these pits and Harthill by the Coltness Iron Co. from their old Polkemmet, Harthill and Muirhead No. 3 shafts. At West Benhar, again, it was worked over a considerable area by Messrs. Addie & Sons. A typical section of the seam at Fauldhouse is given below:—

Fauldhouse and Polkemmet Pits.

			Ft.	In.
Blaes and balls, brushing	.	.	2	6
Maggie blaest	.	.	7 in. to	0
IRONSTONE	.	.	.	10
COAL	.	.	.	4
Fireclay	.	.	2 in. to	0
				6

In the workings near West Benhar the ironstone varied from 6 to 22 in., averaging 14 in.

The Crofthead Slatyband lies 10 to 12 fms. below the Crofthead (or Colburn) Coal. It was considered a very valuable ore, and was

* The Lower is the Goodockhill Ironstone (see p. 107).

† See Glossary, p. vi.

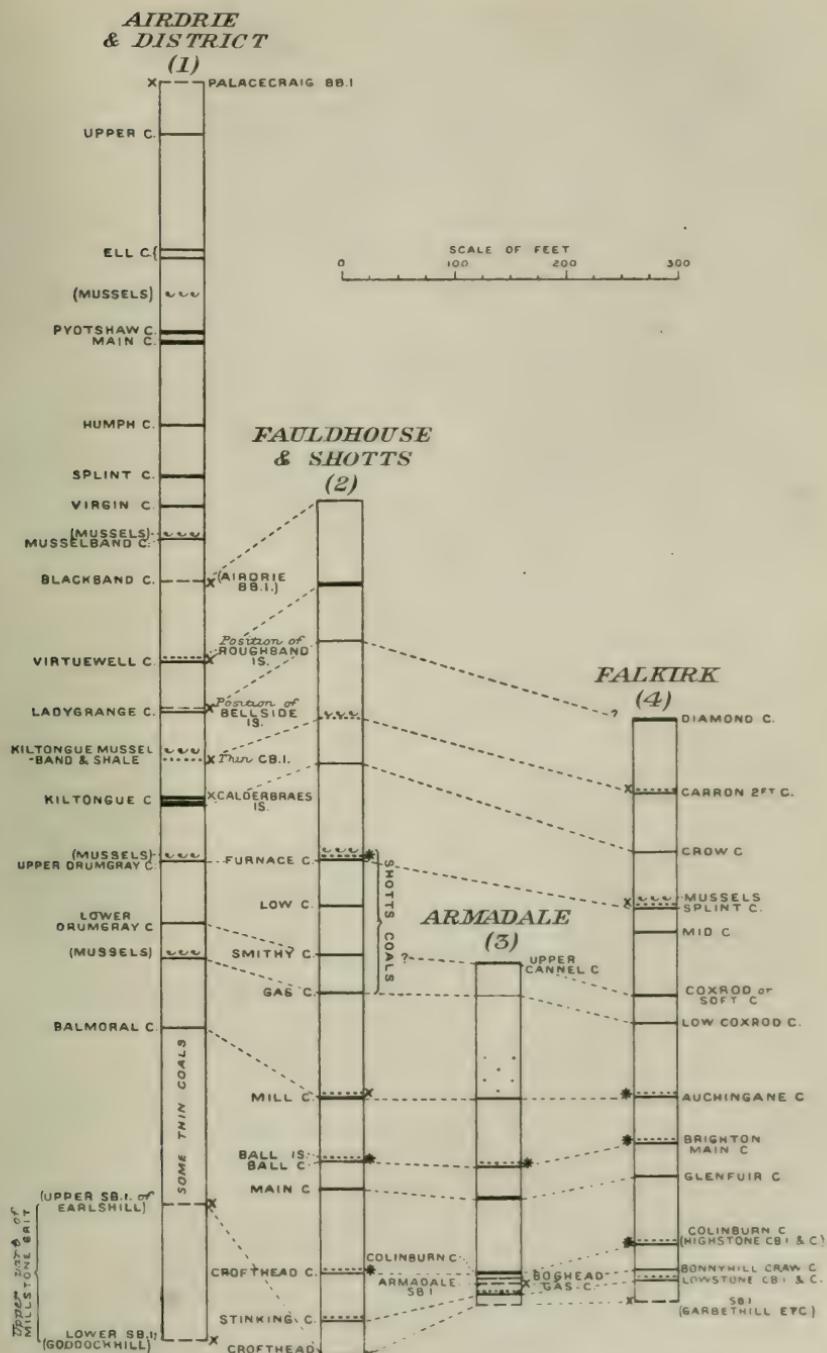


FIG. 11.—Comparative Vertical Sections of Coal Measures, Central Coalfield.

widely and persistently sought after. The horizon has been proved in numerous bores outside the limits of the worked area, and it is unlikely that there is any considerable reserve still to exploit. The boundaries of the old workings are largely defined by an irregular much indented line beyond which the ironstone is "wanting," and considerable "wants" occur within the worked-out area itself. At Back o' Moss, a little north-west of Harthill, and also to the north of Harthill it appears to be generally represented by a foul coal 8 to 15 in. thick overlain by 1 to 2 ft. of blaes containing iron-stone balls. Between Harthill and Longridge it has not been recorded as a workable blackband. To the west of Harthill (at Hassockridge, Dewshill, Duntillan, etc.) its position is occupied by a thin coal. Here and there, of course, it reappears as a blackband, *i.e.* in a bore at Blairmuckhill, where a 12-in. ironstone is recorded at this horizon.

At Brownhill and Longrake, south of West Benhar, the ironstone varies a good deal, but is generally poorly developed. On Cairney-head (Lanark, 13 N.E.) a 7-in. "ironstone" is recorded in the position of the Slatyband, and at Badallan (Lanark, 13 N.E.) a 9 to 10-in. coal generally occupies the same position. A section of the horizon as proved in bores on Knowton reads:—

Blaes and balls				
IRONSTONE			0 to 13 in.	
COAL			3 to 9 „	

but on Headlesscross again (Lanark, 13 S.E.) we find a 7 to 15-in. coal in the same position. There are many old shallow pits to this seam in the ground south of Fauldhouse as far as the east-and-west fault at Wellhill. Little is known of the extent of these workings or of the thickness of the ironstone, but south of this fault it is replaced by a 15 to 18-in. foul coal.

(2) *Upper Slatyband of Earlshill, Slatyband of Moffat Hills (Stepends), Arden (Barblues) and Stanrigg (6-in. Sheet Lanark, 8 N.E.).* Within the area covered by these localities considerable patches of a slaty blackband ironstone have been worked. At Earlshill two slatybands were wrought, of which the lower is on the horizon of the Goodockhill ironstone of the Millstone Grit Series (see p. 48), while the upper lies a few fathoms below the Duntillan Parrot-top or Crofthead Coal, and therefore approximately on the horizon of the Crofthead Slatyband. This correlation is dealt with in the "Summary of Progress" for 1910 (pp. 48–50), and will be fully discussed in the memoir on Area VI. of the "Economic Geology of the Central Coalfield" in course of preparation. Only a very small area of the Upper Slatyband seems to have been worked at Earlshill. The Moffat Hills workings of the Summerlee Iron Company and the Arden workings of the Shotts Iron Company extend roughly from Annieshill northwards to Barblues. The seam was worked over isolated patches separated by "wants" or areas of "thin stone." In the first-named field the section given is—

	Ft.	In.
Fireclay roof		
CROWS	0	6
IRONSTONE (with rib)	0 to 2	6

And at Arden thicknesses of from 5 to 23 in. are recorded.

The Slatyband of the Earlshill-Barblues area was very irregular in occurrence and in thickness. It contained many wants. Locally it showed thicknesses of 2, 3 or even $4\frac{1}{2}$ ft., but thinned away to 2 or 3 in. within a short distance. At Stanrigg Colliery, about 1 mile west of Barblues, an ironstone which is believed to be the Crofthead Slatyband* was formerly worked. The average section of the workings was—

		Ft.	In.
Fireclay, brushing	.	3	0
Fireclay and balls	.	0	10
IRONSTONE	.	2 in. to	0 5
Blaes	.	0 to	0 2
IRONSTONE	.	2 in. to	1 8
COAL	.	0 to	0 3

Although pockets of workable ironstone no doubt exist in the Arden-Earlshill field, it is not likely that there is any considerable reserve. The ironstone is too inconstant in character to repay exploitation under existing conditions. The following analysis of a part of the seam from Brownieside is given by Prentice in a paper on the "Mineral Seams of New Monkland":†—

	Per cent.
Protoxide of iron	54·03
Carbonic acid	33·22
Carbon	6·24
Combined water	2·36
Phosphoric acid	1·14
Sulphide of iron	0·57
Lime	0·86
Silica	1·05
Magnesia	0·53

This analysis shows 42 per cent. of metallic iron. It may be remarked that the carbon percentage is low for a blackband.

(3) *Auldshields Slatyband*.—In the Greengairs-Longriggend coal-field the position of the Crofthead Slatyband appears to be generally marked by a thin coal. At one locality only is a blackband known to occur at this horizon. The natural section exposed in a small cliff on the south side of Auldshields Bridge, about $1\frac{1}{4}$ miles N.W. of Greengairs (Lanark, 3 S.W.), shows:—

Yellow sandstone, massive post of—
PARROT COAL AND BLACKBAND IRONSTONE, 12 in.

The ironstone itself is only 1 to 3 in. thick, however, and although there are old workings in the seam around the bridge, and especially to the S.E. of it, where a pit 17 fms. deep appears to have wrought a considerable area, it can have little economic value. The ore was of poor quality and very sulphurous. The greatest thickness of blackband recorded in bores in the vicinity is 6 in., with an inch or two of coal below. Elsewhere, at Stand, Riggend, Wattston, Luckenhill, Langdales, Arden, etc. (Lanark, 3 S.W., S.E.) the position is represented in bores by a few inches of coal.

(4) *Slatyband of Garbethill, Loanfoot and Roughcastle*.—The Auldshields Slatyband is of interest, because it helps to link up the occur-

* See "Economic Geol. Central Coalfield, Area V.," *Mem. Geol. Surv.*, 1916, pp. 84–5.

† *Trans. Inst. Min. Eng.*, 1896, vol. xii., p. 447.

rence of blackband ironstone at the base of the Coal Measures in the Fauldhouse and Shotts areas with the ironstone locally developed in the same position on the west side of the Falkirk coalfield. Between Beam Farm and Garbethill (Stirling, 30 S.W.) there are a number of old shallow ironstone pits to this horizon. It was last worked for a short time in 1887 from No. 1 Pit, where the seam was 14 fms. deep. No section is recorded, but at one point on the working face a thickness of 18 in. is given. Two bores on Garbethill record the following:—

	Ft. In.		Ft. In.
(1) IRONSTONE	1 8½	(2) Good hard IRONSTONE	0 11½
Daugh	0 2½	Soft ply	0 0½
IRONSTONE	1 2	Good hard IRONSTONE	1 3½

Very probably the thicknesses given are quite exceptional. To the north-east of Beam again, at Loanfoot, the Slatyband was worked over a small area between the years 1878–81. Here it showed:—

	Ft. In.
Blaes roof	
Blaes, brushing	3 4
COAL	0 2
IRONSTONE	0 9

One bore here records 14 in. of coaly ironstone, and another gives 17 in. of blackband on 2 in. of coal. Bores to the south-east of Drum, near the outcrop of the seam, record thicknesses of 10, 10½ and 13 in.

Farther north again, at Bonnyhill and Roughcastle, the slatyband has been wrought to some extent (Stirling, 30 N.W.). At Roughcastle the section shows:—

	Ft. In.
Fireclay (worked)	5 0
BLACKBAND	0 to 0 6
COAL	0 8

Locally the blackband shows "lunkers" of 18 in. It was formerly wrought by the Carron Company from an old day level just south of the present Roughcastle fireclay works. Not far to the north, however, in the cutting on the Caledonian Railway near Tentfield, its position is occupied by a thin coal. At all these localities the ironstone is quite shallow. Probably it deteriorates rapidly eastwards, as it seems to be absent or poorly represented in the central and eastern parts of the Falkirk Coalfield. A blackband with marine fossils is recorded as having been formerly exposed in the Millhall Burn to the east of Polmont, but nothing is known of its thickness or character. It may represent either this horizon or the slightly higher Slatyband of Armadale.

(5) *Crookedstone Slatyband.**—(6-in. Maps Lanark, 17 S.E.; 18 S.W.; 24 N.W.). This horizon has been adopted as the base of the Coal Measures in the Quarter, Larkhall and Stonehouse districts. The evidence for correlating it with the Crofthead Slatyband will be found in detail in the forthcoming memoir on Area IX. of the "Economic Geology of the Central Coalfield" (see also Area VIII., East Kilbride and Quarter; published 1917, pp. 37–8). This blackband is a thin variable seam of very little economic value, but has been worked to a small extent at one or two localities.

* From notes contributed by Mr. C. H. Dinham.

An exposure on the south bank of the Crookedstone Burn, west of the site of Darnagaber Castle (Lanark, 17 S.E.), shows:—

		Ft.	In.
Soft sandstone	at least	20	0
Blaes and clayband balls . . . . .	. . . . .	3	6
BLACKBAND with nodular top and coaly films . . . . .	. . . . .	0	3½
Pyritous rib . . . . .	. . . . .	0	0½
PARROT COAL . . . . .	. . . . .	0	1½
Hard grey fireclay . . . . .	. . . . .	0	5
Soft fireclay with clay and nodules . . . . .	. . . . .	3	0

Another exposure 400 yds. due west of Crookedstone Farm shows a thickness of 4 in. with parrotty partings containing *Lingula*. Workings in this seam began apparently between 1845 and 1868,* and the stone was latterly taken to the now dismantled furnaces at Quarter. Where found in bores the Crookedstone Slatyband is 2 to 7 in.

Larkhall.—The same seam was known here as the *Lower Slatyband of Birkenshaw*, and was worked on a small scale. Old mines to it are visible on the right bank of the River Avon, E. and E.S.E. of Ringsdale Castle. The seam is a striped pyritous blackband never recorded as more than 7½ in. thick, and is commonly associated with parrot coal. It is well seen in natural section to the north of Patrickbrae:—

		Ft.	In.
	Blaes and clayband balls	0	6
	Sulphury blaes	0	1
Lower Slatyband.	Striped PARROT AND BLACKBAND (pyritous)	0	1
	Hard BLACKBAND (pyritous)	0	1½
	Parting	0	0½
	Striped BLACKBAND AND CLAYBAND	0	1
	Parting	0	0½
	Bright COAL	0	0½

It was reached in many borings on the farms of Wellhog, Thinalacres, Broomelton, Kittymuir, Birkenshaw, Holm, Linthwaugh and West Town, but was never thick enough to work, and indeed in most of the bores only parrot coal is recorded.

(6) *Castlehill Slatyband*.—A blackband ironstone at the base of the Coal Measures in the Castlehill area was formerly worked from mines by the Shotts Iron Company about 1865 (Lanark, 19 N.W.). These workings lay on the south side of Bowridge Burn at Bowridge Bridge. The section of the seam in the burn itself is now obscured. In a bore at Hyndshaw, a little to the dip, the horizon showed 7½ in. of slaty ironstone resting on 21 in. of coal, and another bore 160 yds. west of Hyndshaw Road recorded a 10-in. blackband. The Castlehill Blackband is quite local, however, and is not likely to attract further attention.

The above notes cover all the known instances of an ironstone having been worked at this horizon. As already stated, it is often difficult to recognise the position of the Crofthead Slatyband in bores, but it has certainly been passed through in a number of bores in other parts of the Central Coalfield. Data regarding the represen-

* "New Statistical Account of Scotland," vol. vi., 1845, p. 259. W. Grossart, "The Upper Coal Measures of Lanarkshire," *Trans. Geol. Soc. Glasgow*, 1868, vol. iii., p. 107.

tative of this ironstone in the Coatbridge, Airdrie and Clarkston districts will be found in "Economic Geology of the Central Coalfield,"* Here and there a thin ironstone is recorded on what may be the horizon of the Crofthead Slatyband, but nowhere has a workable blackband been found. The same statement applies to the Wishaw, Motherwell and Hamilton fields.

Stinking Coal (Armadale district); *Lowstone Coal and Ironstone* (Falkirk).—These two seams are very probably upon the same horizon.† The Stinking Coal of Armadale varies in thickness from 9 to 15 in. It is, locally at least, very rich in pyrites, and the percentage of sulphur must be considerable. Overlying it there occurs typically a bed of fireclay 3 to 5 ft. thick, containing ironstone nodules. These were wrought at one time to a small extent along with the coal, and are reported to have been in some cases of very large size. The Stinking Coal is present also in the Fauldhouse district, and shows much the same features as at Armadale. The Lowstone Coal of the Falkirk field again is some 6 to 12 in. thick, and is overlain by about 1 ft. of blaes, above which comes a 6-in. layer of clayband balls. To the latter the name Lowstone was given. The horizon is exposed in the Fauchlands railway cutting to the west of Falkirk (Stirling, 30 N.W.), and in old pits on Tentfield Plantation, just south of the cutting, the seam was formerly worked to some extent by the Carron Co. (see note on Highstone, p. 118, and cf. p. 7). It appears to be of local occurrence here, and is absent or not recorded in the central part of the Falkirk Coalfield.

Armadale Slatyband Ironstone.—(6-in. Maps, Linlithgow, 8 N.E., S.E.; 9 N.W., S.W.). This is a variable seam of blackband ironstone which occurs as a workable subject within a radius of approximately 1 mile of the village of Armadale. The ironstone is closely associated with the once famous Boghead Cannel which lies a few feet below the Colinburn or Crofthead Coal. On the south side of the 45-fm. fault known as the Heatherfield Dyke, which runs in a general north-westerly direction a little to the north of Armadale, the slatyband has been worked in pits at Woodend, Armadale, Hopetown and Bathville. It reaches here a thickness of as much as 27 in., but contains "wants" and areas of "thin stone." Where the Boghead Cannel was best developed as on Boghead and Torbanehill the slatyband is absent or very poor, and west of Bathville, towards Northrigg and Blackrigg, both horizons thin rapidly away. Two old bores at Boghead and Bathville record:—

Boghead No. 3 bore.

	Ft.	In.
COLINBURN COAL	2	9
Coaly blaes	1	0
Fireclay	2	10
Cement	0	2
PARROT COAL	0	11
Fireclay (with a 4½ in. ironball)	0	11
FOUL COAL	0	9

Bathville No. 1 bore.

	Ft.	In.
COLINBURN COAL	2	9
Fireclay	2	2
Ironstone	0	3
GAS COAL	1	0
Fireclay	0	10
{ PARROT AND IRONSTONE		1
BLACKBAND	0	8

* "Economic Geology Central Coalfield, Area V.," *Mem. Geol. Surv.*, 1916, pp. 36-8 and 83-5.

† See "Economic Geology Central Coalfield, Area II.," *Mem. Geol. Surv.*, 1917, p. 68.

Farther north near Armadale an old bore gives the following section:—

	Ft. In.
COLINBURN COAL	4 0
Fireclay	1 2½
PARROT (BOGHEAD CANNEL)	0 8½
Fireclay and fakes	2 3
BLACKBAND	0 10

The parting appears to increase at Barbauchlaw where we find:—

COLINBURN COAL.
Fakes and fireclay, 5 ft. 9 in. to 8 ft. 0 in.
BOGHEAD CANNEL, thin and variable.
Fakes and fireclay, up to 8 ft. 6 in.
SLATYBAND, variable.

At Woodend No. 5 Pit, the ironstone averaged 12 in., varying where worked from 6 to 16 in. On the north side of the Heatherfield fault, in the little basin of Coustoun (Linlithgow, 9 N.W.), the following section is recorded:—

	Ft. In.
COLINBURN COAL	3 0
Fireclay	6 0
PARROT (BOGHEAD CANNEL, 2 to 22 in.)	1 0
Fireclay	3 0
BLACKBAND (3 to 9 in.)	0 6
COAL	0 2

It would seem upon the whole that the Armadale Slatyband lay generally a few feet below the Boghead Cannel, and extended north-westwards as a workable subject (*i.e.* to Woodend No. 5 Pit) farther than the latter. At some points the seams were so close together as to be regarded as one horizon. This slatyband is confined to the Armadale coalfield, and has been largely worked out. There is still a little ore available to the west of Armadale, near Woodend, but no large reserve could be expected. Elsewhere, wherever the position has been recognised, it is represented by a foul coal. Thus in the Falkirk field the Sulphur Coal of Candie and Redford, the Red Coal of Bowhouse and the Craw Coal of Bonnyhill are probably on the horizon of the Armadale Slatyband.*

Clayband ribs overlying the Colinburn (or Crofthead) Coal.—This coal is a workable subject only along the eastern edge of the Central Coalfield, in the Falkirk, Armadale and Fauldhouse districts. Locally these impersistent ribs of clayband are found above it.

(1) *Falkirk Coalfield.*—The coal varies from about 18 to 20 in. in the north part of the field around Polmont and Manuelrigg to 24 or even 30 in. farther south at Redford, Blackstone and Hill Farm. "It was almost certainly this seam which was wrought from an old pit near Wester Bowhouse under the name of the Speckle Ball Coal."† Here the section was:—

	Ft. In.
IRONSTONE	0 4
PARROT	0 9
FREE COAL (COLINBURN)	2 0
Fireclay	2 0
RED COAL	1 6

* See "Economic Geology of Central Coalfield, Area II," *Mem. Geol. Surv.* 1917, p. 68.

† *Ibid.*, p. 67.

The term Speckle Ball refers to the ironstone forming the roof. At present the seam is worked at Hill Farm Colliery, Avonbridge (since 1914). At Bonnyhill, to the west of Falkirk, the Colinburn seam has been known as the Highstone Coal. A rib of clayband, about 4 in. thick, occurred a foot or two above it, and was known as the Highstone. Both coal and ironstone were formerly wrought from shallow pits in the Tentfield Plantation (Stirling, 30 N.W.) along with the underlying Bonnyhill Craw Coal, Lowstone and Lowstone Coal.

(2) *Armadale Coalfield*.—The Colinburn Coal in this district is about 30 in. thick, and is typically underlain by about 3 ft. of good quality fireclay. No ironstone is recorded as associated with this seam in any of the abandoned or present workings.

(3) *Fauldhouse*.—*Shotts Basin*.—The Crofthead Coal is at present mined at Badallan (Lanark, 13 N.E.; $\frac{2}{3}$ mile south of Fauldhouse Station), where the section shows:—

	Ft. In.
Blaes	1 6
CLAYBAND	4 in. to 0 6
Daugh	0 2
COAL	2 ft. 9 in. to 3 0
Sandstone	

The same coal as recently opened at Parkfoot Colliery, Shotts (Lanark, 13 S.W.), shows:—

	Ft. In.
Blaes and CLAYBAND ribs	
COAL	1 ft. 9 in. to 2 3
Fireclay and small clayband balls	

The clayband ribs here are found to be impersistent, but one or more is always present. They are lenticular, reaching when thickest 6 or 7 in., and thinning away to nothing. At both these localities the clayband from the brushing is collected until sufficient has been gathered for transmission to the blast furnaces at Shotts. The supply is very small and irregular.

Ball Ironstone.—This name is given to a bed of clayband nodules overlying the Ball Coal of the Fauldhouse, Armadale and Falkirk coalfields.

(1) *Falkirk Coalfield*.—This field is taken here as extending from Falkirk and Polmont southwards to the River Almond. The Ball Coal and Ironstone seam is raised from Meadowbank, Redding, Manuelrigg, Muiravonside and East Roughrigg Collieries. In the northern part of the field at Meadowbank and Redding the coal is in two leaves, and the ironstone occurs as a local development of the stone parting separating these. An average section at Redding shows:—

	Ft. In.
Blaes	
Dirt and Coal	0 8
COAL, variable	1 5
Stone rib	3 in. to 2 0
COAL	1 2
Coaly daugh	0 4

The ironstone which locally replaces the stone rib varies from 0 to 14 in. The Ball seam was wrought long ago * at Brightons and

* At Brightons as early as 1768. See Mushet, "Papers on Iron and Steel," 1840, p. 117.

Maddiston by the Carron Company, partly for the sake of the associated ironstone. At Brightons, to the west of the quarry in the thick sandstone which overlies the coal, the latter is stated to have been $4\frac{1}{2}$ ft. thick, with several stone ribs. "Immediately above it," says the "New Statistical Account of Scotland,"* "are two or three bands of ironstone which has long been worked by the Carron Company and others, and is now nearly exhausted."

At Manuelrigg Colliery the seam shows:—

		Ft.	In.
Blaes	.	12	0
BALL IRONSTONE	.	up to	0 4
Blaes	.	0	3 $\frac{1}{2}$
BALL IRONSTONE	.	up to	0 2
Blaes	.	0	6
COAL	.	0	3
Sclitty COAL	.	0	6
COAL	.	0	10
Black fireclay	.	0	8
COAL	.	0	10
Fireclay, with occasional large ironstone balls	.	1	1
COAL	.	1	5

Farther south again, at Muiravonside, East Roughrigg, Blackstone, Redford, Hill Farm, etc., the coal is in one leaf with a bed of ironstone balls immediately or very close above it. The same condition holds throughout the Armidale field, and it seems very possible, as Mr. Anderson has suggested,† that only the lower leaf of the Ball Coal of the Redding-Polmont area corresponds to the Ball Coal of Armidale and of the southern part of the Falkirk field. The general section of the seam in the latter area shows:—

	Ft.	In.
Sandstone, roof		
Blaes	0 to	3 6
CLAYBAND BALLS	0 to	3 0
COAL	14 in. to	2 2
Daugh	0	4
Sandstone, pavement		

The ironstone bed varies greatly from point to point, sometimes consisting of a closely-packed layer of nodules 6 to 10 in. thick, sometimes of balls scattered irregularly through 2 or 3 ft. of blaes. Locally the overlying sandstone is separated from the coal by only an inch or two of blaes, and occasionally nodules of ironstone occur in the upper part of the coal itself. East of the above localities, at Gardrum, Easter Jaw, etc., the Ball Coal is too thin to work.

(2) *Armadale Coalfield*.—The Ball Coal and Ironstone is raised at the following pits: Craigrigg, Northrigg No. 2 and 7, Armidale, Blackrigg, Westrigg and Southrigg. Craigrigg lies $1\frac{1}{4}$ miles north of Armidale; Northrigg Colliery lies about $1\frac{1}{2}$ miles south-east of Armidale; the others west-south-west or south-west of it. The Ironstone appears to be thicker in the eastern part of the field, and was formerly worked with the coal at various pits at Bathville, Boghead and Armidale. The sections at Bathville No. 3 Pit, at Boghead No. 10, and at Trees Nos. 1 and 2 showed:—

* Vol. viii., 1845, p. 192.

† See "Economic Geol. Central Coalfield, Area II.," *Mem. Geol. Surv.*, 1917, p. 70.

	<i>Bathville.</i>		<i>Boghead.</i>		<i>Trees.</i>	
	Ft.	In.	Ft.	In.	Ft.	In.
Blaes .	. 1	2	. 0	6	. 1	6
BALLS .	. 0	4	. 0	8	. 0	2
COAL .	. 2	0	. 2	2	. 2	0

The Ironstone consists of an almost continuous layer of clayband balls; it varies from 1 to 24 in. in the Northrigg workings, but west and south-west of Armadale is generally only 3 or 4 in. thick. Other names for the Ball Coal in this field are the Woodend Ironstone Coal or Colinshields Coal.

(3) *Fauldhouse Coalfield*.—The Ball Coal and Ironstone seam is worked at Crofthead Collieries, where it shows the following section:—

		Ft.	In.
Sandstone			
Fireclay	.	.	. 1 4
Blaes 0 6
IRONSTONE 0 2½
Blaes 0 6
COAL 2 0
Fireclay			

At Cultrigg Colliery, which lies about 2 miles a little west of north of Fauldhouse, it is much the same. It was formerly raised at Badallan and at East Benhar, where the sections were:—

<i>Badallan.</i>			<i>E. Benhar Pit No. 13.</i>		
	Ft.	In.		Ft.	In.
Blaes and IRONSTONE Balls .	2	0	Blaes .	.	. 1 6
Blacks .	. 0	8	COAL .	.	. 1 9
COAL .	. 2	3	Daugh .	.	. 0 6
Fireclay .	. 0	7			

Considerable areas of this seam still remain unworked. The balls in the overlying blaes constitute a characteristic feature of it, and will doubtless continue to yield a small supply of ore where the coal is worked. West and north-west of Shotts, however, the Ball Coal is poorly developed.

*Overwood Claybands**.—The Ball and Main Coals of the Armadale and Fauldhouse fields are known to deteriorate when followed to the west and south-west. Their position south of the Clyde cannot be accurately fixed, but they are possibly represented in bores by a generally well-marked horizon of fireclays containing ironstone balls. At Overwood, for example, in 6-in. Map, Lanark, 24 S.W., the section of the horizon is:—

	Ft.	In.
Sandstone		
Faky blaes .	.	. 1 0
Blaes with 6 CLAYBAND ribs .	.	. 2 10
Coaly blaes .	.	up to 0 6
Fireclay, partly faky .	.	. 10 0

The clayband ribs of this section amount in all to 17½ in. of ironstone, and there is reason to believe that they were at one time leased to the Glasgow Iron Co. along with the Watstone Musselband seam which lies some 16 fms. higher in the sequence. It is not known, however,

* From notes by Mr. C. H. Dinharn.

if they were ever wrought. These claybands are confined to the neighbourhood of Watstone, and do not appear in sections of the same horizon elsewhere, e.g. in the River Avon. The following additional data are taken from bores in the vicinity of Watstone :—

Bore in Watstone Pit ;	$14\frac{1}{2}$	in. of clayband in	32	in. of blaes.
Bore on Burncrooks ;	$14\frac{1}{2}$	"	34	"
18	"	32	"	
Bores on	$17\frac{1}{2}$	"	31	"
Watstone	$6\frac{1}{2}$	"	18	"
and	$14\frac{1}{2}$	"	31	"
Spital	8	"	21	"
	14	"	30	"

In all cases the roof is of sandstone and the pavement of fireclay.

It is quite possible that these Overwood Claybands may represent the Ball Ironstone and Coal position.

Clayband ribs above the Mill Coal.—This coal has a somewhat wider extension as a workable subject than the Ball Coal 8 fms. below it, but, like it, is best developed along the eastern edge of the Central Coalfield. In the Falkirk district it is known also as the Auchingane Coal, and east of Coatbridge as the Balmoral or Clefted Coal. Very often it contains an upper rib of excellent parrot coal, and has been known as the Crofthead Gas Coal or Blackhall Parrot from the localities in the Shotts-Fauldhouse basin.

Locally the roof contains lenticular ribs of clayband ironstone. A "General Section of Strata at Bentend and Auchingean Colliery," dated 1869, gives the following section :—

	Ft. In.
Blaes	2 8
CLAYBAND IRONSTONE	0 4
Blaes	0 6
IRONSTONE, shelly, mixed with blaes	0 6
PARROT COAL, inferior	0 8
SOFT COAL	1 8
Fireclay	0 6

It was wrought here partly for its ironstone. The coal has been worked at Craigend and other localities, and is still raised at Callander, Meadowbank, Muiravonside, Manuelrigg, Easter Jaw, etc. The blaes overlying it frequently contain a thin clayband rib which is taken out in the brushing. A typical section is given below :—

	Ft. In.
Blaes roof	
Blaes and balls brushing	2 6
CLAYBAND BALL, irregular and local	0 4
PARROT OR GAS COAL	0 4
COAL (14 to 24 in.)	1 8

A small supply of ironstone is got from this seam from time to time.

In the Armadale and Fauldhouse fields the section is very similar to that given above. The coal is 2 ft. to 2 ft. 4 in. thick on an average, and is overlain by a few feet of blaes and ironstone balls with locally an impersistent and lenticular clayband rib. The same is the case in other areas, e.g. Castlehill, Morningside, Carron, etc.

*Upper Slatyband of Larkhall District.**—This horizon in the Lark-

* From notes contributed by Mr. C. H. Dinharn.

hall district corresponds approximately to the Mill Coal of the Shotts-Fauldhouse coalfield. For the evidence on which the correlation is based and for additional information regarding the seam, reference may be made to the forthcoming memoir on the "Economic Geology of the Central Coalfield, Area IX."

The seam was formerly wrought from mines extending beneath Cherry Hill, south-east of Larkhall Viaduct. There are also old crop workings at other parts of the gorge of the River Avon between this point and Stonehouse. The best section now visible lies on the left bank of the Avon, 170 yds. E.N.E. of Patrickholm, 50 yds. above the waterfall. It reads as follows:—

		Ft. In.
	Blaes	
	Blaes, somewhat parrotty	1 0
CHERRYHILL	{ BRIGHT COAL, iron pyrite at base	0 8
SLATYBAND	{ BLACKBAND (with laminae of parrot coal).	0 6
	Fireclay, fakes or blaes, with balls and ribs of	
	CLAYBAND	4 4
WELLBOG	{ PARROTY BLAES	4 to 0 7
MUSSELBAND	{ CLAYBAND with "mussels"	2 to 0 4
	Blaes or fireclay with CLAYBAND balls	6 0

To the thin blackband ironstone, wrought to some little extent as mentioned above, the name *Cherryhill Slatyband* has been given for convenience of reference. The underlying "musselband" is again seen on the right bank of the Avon, 200 yds. S.W. of Linthaugh Bridge, Stonehouse, but in this section the Slatyband is represented by a 12-in. coal. The section reads:—

		Ft. In.
	COAL (WELLBOG COAL) formerly exposed	1 0
	Fireclay with CLAYBAND nodules	4 0
WELLBOG	{ PARROT COAL with a 2-in. CLAYBAND rib	0 7½
MUSSELBAND	{ PARROTY CLAYBAND with "mussels".	0 4
	Blaes	7 6

The *Wellbog Coal* is proved in many bores on Wellbog, Thinacres and Broomelton to be 14–18 in. thick, and to lie 1 or 2 ft. above the Wellbog Musselband. It seems clear that the Slatyband of Cherryhill is only a local variation of the Wellbog Coal of Quarter.

On the same horizon lies the *Upper Slatyband of Birkenshaw*.* This seam, which is found also at Plotcock and Thinacres farther east, appears to represent both the Wellbog Coal (or Cherryhill Slatyband) and the Wellbog Musselband of the sections given above. The Upper Slatyband of Birkenshaw was wrought from its crop in the River Avon by the Coltness Iron Company. Near the river it shows in natural sections:—

		Ft. In.
	PARROT COAL and BLACKBAND	0 2
	HARD BLACKBAND	1 0

Bores in the neighbourhood show 4 to 14 in. of coal (partly parrot), resting on 3 to 9½ in. of blackband. Near Thinacres, again, a trial pit put down at the side of the Plotcock Burn about 1845 found "a seam of blackband ironstone containing 'mussels'; top ply coaly 7 in., under ply fairish ironstone 9½ in."

* For the Lower Slatyband of Birkenshaw, see p. 115.

*Watstone Musselband Ironstone.**—This seam takes its name from the farm of Watstone, near Stonehouse, on which it was at one time wrought (Lanark, 24 S.W.). It is a variable seam of clayband ironstone with "mussels," associated with parrot coal, free coal and occasionally blackband ironstone. It is seen at a few places in the gorge of the River Avon, the most northerly exposures being in the right and left banks, 80 yds. E.S.E. and 70 yds. S.S.W. respectively of the point where the Larkhall Viaduct crosses the river (Lanark, 18 S.W.). The clearest section, however, is in the right bank of the Avon, south-west of the garden square at Cherryhill (Lanark, 18 S.W.), where the following beds are exposed at this horizon:—

	Ft. In.
Blue blaes with ribs of irony fake	7 0
Strong blue blaes	0 6
Parrotty blaes	0 6
PARROT COAL with lenticular streaks of clayband and many large "mussels" (<i>Carbonicola</i>)	0 5
BRIGHT FREE COAL	0 7
Fireclay and faky fireclay	1 4

The parrot and free coal together constitute the Watstone Musselband seam. Other exposures are found on the left bank of the Avon, 70 yds. due E. of Patrickholm, and at the top of the right bank 300 yds. E.N.E. of the same place (Lanark, 18 S.W.). Here the seam shows:—

	Ft. In.
PARROT COAL and COALY IRONSTONE	0 3
CLAYBAND with coaly streaks ("mussels")	0 1½
BRIGHT COAL	

The greatest thickness of the seam is found around Watstone, Stonehouse. The following details, taken from bores in the neighbourhood, will serve to illustrate the variable character of the seam.

On Burncrooks.—Parrotty blaes 15 in., "mussel" ironstone 22 in., shale and blaes 18 in., "mussel" ironstone 6 in., irony parrot 9 in., blackband 8 in., shale with 2 in. ironstone 35 in.

On Watstone.—Parrot 16 in., "mussel" ironstone 11½ in., brown ironstone 7½ in.

On Dovesdale.—Parrot 26 in., parrot and ironstone 16 in., shale 11 in., coal 6 in.

On Hamilton Farm.—"Mussel" ironstone 19 in., shale 7 in., blackband 7 in., irony parrot 4 in., "mussel" ironstone 3 in., irony parrot 7 in., shaly blaes 6 in., "mussel" ironstone 22 in.

On Overwood.—Wild parrot 8 in., "mussel" ironstone 12 in., blackband 7 in., shale 7 in., "mussel" shale 10 in., coal 3 in.

On West Town.—Ironstone 3 in., shelly band 3 in., ironstone 4 in., parrot and ironstone 11 in., coarse ironstone 3 in.

The most recent workings in the seam were from a pit situated 800 yds. S.S.E. of Watstone Farm, where about 12 acres of stone were taken out between 1861 and 1865. In the Overwood (or Dovesdale No 12) Pit, the site of which is now occupied by Overwood Quarry, the Watstone Musselband seam was 12 to 16 in. thick, and about 2 acres seem to have been wrought at a depth of 32 fms. in 1866-7. Nowhere else apparently has the ironstone been wrought except

* From notes contributed by Mr. C. H. Dinham.

perhaps at its outercrops in the River Avon at Stonehouse Viaduct and at Birkenshaw, where it was called a blackband. Its absence from these natural sections points to old workings.

Just north of the area referred to above, and in the neighbourhood of the Avon, the same horizon has been proved in many bores (Lanark, 24 N.W.) :—

On Kittymuir.—8 to 18 in. ironstone recorded.

On Birkenshaw.—Shaly blaes 18 in., "mussel" ironstone 14 in., foul coal 6 in.

On Struther.—Foul parrot 26½ in., ironstone ½ in., coarse "mussel" ironstone 12 in., parrot 7 in.

On Cander Mill.—Coal 9 in., ironstone 12 in.

On Cander Mains.—Parrot 4 in., "mussel" ironstone 11 in., parrot 4½ in., "mussel" ironstone 6 in.

In No. 2 Pit, Canderigg Colliery, only 2 in. of ironstone are recorded in 4 ft. of "mussel"-shale. Thin ironstone ribs associated with "mussel"-shale are also found at this horizon at Swinhill and Millburn (Lanark, 24 N.W.).

This ironstone is confined to the Stonehouse district, outside of which it has never been proved of the least value. The Watstone Musselband horizon itself can be followed over a wide area, but elsewhere is represented by a thin coal overlain locally by parrotty blaes.

From its relations to the Kiltongue-Drumgray group of coals and the occurrence of "mussels" in association with it, this seam may confidently be correlated with the Shotts Gas Coal.

Ironstone balls above Upper Drumgray Coal.—This seam is known also in the Falkirk Coalfield as the Splint, Carron Main, or Hard Coal, in the Shotts-Fauldhouse basin as the Shotts Furnace or Ball Coal, and at Castlehill as the Two-foot or Second Coal. It has, of course, a much wider distribution in the Central Coalfield than these localities indicate. The coal is characteristically overlain by a bed of blaes of variable thickness containing, locally, scattered ironstone balls. It is also noteworthy from the occurrence of a "musselband" not far above the coal. The balls of ironstone have long been wrought in the Shotts and Castlehill fields. The bed in which they occur is only 2 to 4 in. thick upon an average, and the supply of ore is small and variable. It is now being worked along with the coal in pits at Fauldhouse, Shotts and Castlehill, the balls being obtained during the brushing of the seam. Three sections of this coal are given below :—

- (1) Craigend, Falkirk Coalfield (Stirling, 31 S.W.).
- (2) Fallahills, Fauldhouse Coalfield (Linlithgow, 11 S.E.).
- (3) Calderhead, Shotts Coalfield (Lanark, 13 N.W.).

	(1)	Ft.	In.
"Mussel" bed			
Blaes	.	0	6
WILD COAL	.	0	4
Fakes and sandstone	.	2	3
BLAES AND BALLS	.	0	9
FREE COAL	.	0	2
SPLINT COAL	.	1	6
FREE COAL	.	0	10
Fireclay pavement			

(2)

	Ft.	In.
Fakes and blaes	0	11
Ironstone ball	0	2
" Mussel " blaes	0	3
Blaes	0	4
IRONSTONE BALLS	0	3
Blaes	1	1
COAL	1	10
Faky fireclay		

(3)

Dark fakes	3	0
" Mussel " ironstone	2 to 0	3
Blaes	9	6
IRONSTONE BALLS	0	3
Blaes	0	9
COAL	2	6

At Castlehill the layer of balls is 4 to 6 in. thick where present. The Furnace or Ball Coal at Shotts was formerly known as the Shotts First Ironwork Coal. Probably the working of the balls began at the time of erection of the ironworks about 1802. At Castlehill the same horizon was wrought at least as early as 1839.

Kennelburn or Calderbraes Ironstone.—This ironstone is found only in a small area near Calderbank and Chapelhall, and corresponds to the upper leaf of the Kiltongue Coal of Airdrie. The ironstone was formerly wrought at its outcrop in the Calder Water at Calderbraes and in the Kennel Burn—both localities being in the south-east corner of 6-in. map Lanark, 8 S.W. The following section of the seam is exposed in the Kennel Burn, near the mouth of an old adit 30 yds. east of the railway:—

	Ft.	In.
BLACKBAND with rare "mussels"	1	3
Blaes with a 3-in. CLAYBAND rib	1	3
COAL	0	10
Blaes with CLAYBAND lenticles up to 6 in. in thickness; base not seen.		

At the old Peep o' Day Colliery, just north of Calderbank, and in the Monkland Collieries, the sections are recorded as follows:—

Peep o' Day Colliery.

	Ft.	In.
FREE COAL	0	4
GAS COAL	0	6
Blacks	1	3
BONNETS *	1	3
IRONSTONE	0	8
Fireclay	0	4

Monkland Collieries.

	Ft.	In.
ROUGH COAL	0	4
GAS COAL	0	4
GAS SHALE	1	1
IRONSTONE	0	6
Black shale	0	5

The parting separating this upper leaf from the lower leaf appears to vary from 1 in up to 18 ft. The gas coal extends as far north-westwards as Rochsolloch and Airdrie; but the blackband and shale do not accompany it far in that direction. In the old Jenny Lind Pit at Chapelhall a bore showed only 5 in. of ironstone.

* See Glossary on p. vi.

To the south of Calderbank, again, the seam was raised over a small area at No. 1 Pit, Woodhall, where it showed:—

	Ft.	In.
FREE COAL	0	5
GAS COAL	0	4
Selit	0	4
SHALE	1	10
IRONSTONE, inferior	1	1
Selit	0	6
Fireclay	0	6
COAL	1	5

These workings, which ceased in 1893, were opened out by a mine from the Lower Drumgray Coal.

Kiltongue Musselband Shale and Ironstone.—This well-known horizon lies towards the middle of the Productive Coal Measures, a few fathoms above the Kiltongue Coal. Having a wide distribution, and being generally easily recognised in bores, it forms an invaluable index-mark for the Kiltongue-Drumgray group of coals below.

The average section shows a foot or two of parrotty blaes passing down into a few inches of good cannel which rests in turn upon 7 or 8 in. of shale crowded with "mussels" and having near its base a rib of clayband ironstone. The ironstone is irregular, generally 2 or 3 in. thick, but locally reaching 10 in. Where 2 or 3 ft. of "shale" are recorded at this horizon, it probably means that the parrotty blaes, cannel and "mussel" shale have not been distinguished. The associated ironstone, which may, or may not, contain "mussels," has been tested for use as an iron-ore, but is of very inferior quality. A bore put down 200 yds. W. of Woodend Loch (Lanark, 7 N.E.) obtained at this horizon:—

	Ft.	In.
Shaly blaes	1	9
"Mussel" ironstone	0	3
Shale	0	3
Ironstone	0	2

On analysis the "mussel" ironstone yielded 16·64 per cent. of iron, the lower 2-in. rib only 11·75 per cent. At Fence Pit, Aucheneath (Lanark, 24 S.E.), a 7-in. "mussel" ironstone recorded at the same horizon was found to contain only about 23 per cent. of FeO.

The economic value of the Kiltongue Musselband depends mainly on its associated shale, and any iron-ore obtained is really of the nature of a bye-product. The seam has been worked on a small scale at a few localities, with a view to the extraction of oil, e.g. in the Rawyards-Clarkston district, where the shale is said to have yielded 30 gallons of oil per ton; in the Greengairs-Longriggend field; at Southfield, Slamannan; at Swinhill, Kittymuir and Birkenshaw (23 gallons a ton), in the Larkhall district: and at Fence Pit, Aucheneath.

In the Banknock, Coneypark and Dennyloanhead fields the Kiltongue Musselband horizon is represented by the Shale Coal. This seam of coal is closely overlain by a rib of ironstone, sometimes with "mussels," and 5 to 8 in. thick; above it comes a 5 to 9-in. "oil shale," which gives the seam its name. In the Falkirk district, the Miller or Carron Two-foot Coal, occupying the position of the Kiltongue Musselband of Lanarkshire, has a thin rib of "mussel"

ironstone above it. The section of this seam at Blackbraes (Stirling, 30 S.E.) showed :—

		Ft.	In.
IRONSTONE	.	0	5
COAL	.	0	3
Faky blaes	.	1	3
COAL	.	0	10

Bellside Ironstone.—This is a blackband ironstone of very limited distribution. Workings in it have long been discontinued, and very little is known about it. It lay approximately 6 fms. under the Virtue-well Coal, and occurred only over a narrow strip of ground extending northwards from Wishaw almost to Goodockhill. It was wrought in a number of pits at Bellside, Auchinlea, Greenhill and Hareshaw about the middle of the nineteenth century, when the demand for blackband ores was at its height. Grossart writing in 1868 describes it as a "blackband, six inches thick, and of excellent quality, but very local, having only been wrought at Bellside and Greenhill, in the parish of Shotts."* The most recent workings in the seam appear to have been at Langbyres, just north of Omoa Station and adjoining the old Bellside workings. Only a few acres were worked here about the years 1862–78, and the seam showed :—

	Ft.	In.
Fakes	4	0
Blaes	2	0
BLACKBAND	0	5
COAL	0	2

The seam thinned away westwards, and was only $2\frac{1}{2}$ in. at Know-noblehill. Southwards it was more persistent, however, and was worked to a small extent at Wishaw. In an old pit at Cambusnethan, just west of the Branchal road, it was 5 or 6 in., but impersistent. Bores at Wishaw record thicknesses of 7 and 10 in. At Hareston-hills, to the south-east of Cambusnethan, the horizon shows only 3 in. of blackband. In other districts it has no value.

Roughband Ironstone.—This name was given to an irregular clay-band ironstone rib lying a few feet above the Virtue-well Coal in the Cleland and Newarthill area (Lanark, 12 S.W., S.E.). The coal and ironstone were worked over a considerable area between Cartin and Cleland House as late as 1878–82, and showed here the following section :—

Carfin.	Ft.	In.	Cleland.	Ft.	In.
Sandstone roof			Sandstone roof		
Fireclay	1	0	Fireclay	1	0
CLAYBAND	0	8	CLAYBAND	0	8
Slaty daugh	0	4	Slaty daugh	0	4
White blaes	2	0	White blaes	6	3
Black blaes	1	0	Black blaes	1	0
Black shale	0	4	Black shale	0	6
Black blaes	1	0	Slaty blaes	0	6
COAL	2	4	COAL	2	6
Daugh	0	4	Daugh	0	3
Fireclay pavement			Fireclay pavement		

* "Upper Coal Measures of Lanarkshire," *Trans. Geol. Soc. Glasgow*, 1868, vol. iii., p. 103.

At Knownoblehill No. 4 Pit (Lanark, 12 S.E.) a few small areas of the Roughband were opened out about 1872-86, and the section of the seam showed:—

		Ft.	In.
Blaes	.	1	0
Hard rock	.	0	6
Fireclay	.	1	6
ROUGHBAND IRONSTONE.	.	0	6
Blaes	.	1	0
CLAYBAND, foul	.	0	5

lying a few feet above the Virtuewell Coal. It is a clayband horizon of limited distribution, and appears to be best developed in the ground extending from Carfin and Cleland southwards to Wishaw. In the field of the Over, Middle and Nether Johnstone Collieries (Lanark, 12 S.W., S.E.), it is somewhat thicker, and lies nearer the Virtuewell Coal than it does farther north. The general section here is:—

		Ft.	In.
Blaes	.	1	0
CLAYBAND	.	1	2
Faky fireclay	.	0	10
Shaly blaes	.	2	6
COAL	.		

At Wishaw (Lanark, 18 N.E.) the Roughband varies from 0 to 8 in. and lies 4 to 6 ft. above the Virtuewell Coal. East of Wishaw, on Greenhead, we find the following section:—

		Ft.	In.
CLAYBAND	.	0	6
Fireclay	.	1	2
Fakes and fireclay	.	4	5
VIRTUEWELL COAL	.	1	10

On Harestonhills and Lanniesmuir thicknesses up to 15 in. are recorded, and here the ironstone lies as much as $3\frac{1}{2}$ fms. above the coal. It seems likely that the term "Roughband" is applied indiscriminately to the thickest of several impersistent nodular ironstones associated with the blaes and fireclay overlying the Virtuewell Coal. To the west of Wishaw (Lanark, 18 N.W.) two sections may be recorded:—

Bore on Shieldmuir.

	Ft.	In.
CLAYBAND	.	0 8
Fireclay	.	1 5
Black blaes	.	0 1½
VIRTUEWELL COAL	.	2 0

Shields Colliery Shaft.

	Ft.	In.
COARSE SANDY IRONSTONE	2	0
Shaly blaes	.	1 4
VIRTUEWELL COAL	.	2 10

Locally in the Motherwell and Hamilton fields ribs of 4 or 6 in. are recorded in this position, but very often the horizon is absent or represented only by scattered clayband balls. An analysis of the Roughband from the Carfin workings has been kindly supplied by Messrs. Wm. Dixon & Co. Ltd.

	Raw.	Calcined.	
		1.	2.
	Per cent.	Per cent.	Per cent.
Iron	31·51	44·40	38·08
Insoluble	9·50	11·50	18·85
Phosphorus	1·01	1·34	1·29
Sulphur	0·137	0·453	0·35
Calcium carbonate	10·89	...	...
Lime . . . .	...	7·80	7·0
Manganese	1·16	1·72	1·80
Loss on calcination	32·15	...	...

At Quarter, to the south of Hamilton, the characteristic sequence at this horizon is as follows:—*

Black blaes, with some clayband ribs	4 to 8 ft.
ROUGHBAND IRONSTONE	0 to 16 in.
Fireclay and faky blaes, with occasional clayband ribs	6 to 14 ft.

Here the Roughband Ironstone itself is a lenticular impure limy clayband.† Where thin it may be comparatively rich, but in a few yards the seam may thicken out to an ochreous-weathering siliceous kingle. An old analysis of the ironstone from Birkenshaw, 4 miles S.E. of Quarter, gave FeO 11·3, CaO 20·3, MgO 8·9, CO₂ 32·6, Al₂O₃ 10·6, SiO₂ 15·8 per cent.; on calcination it yielded 18·8 per cent. of Fe₂O₃.

In the Greengairs field‡ the Virtuewell Coal, now practically exhausted, was about 3 ft. thick, and had a roof of oil-shale 12 inches or more in thickness. Five or six fathoms above it is found a clayband ironstone which is well exposed in the Cameron Burn, 300 yds. east by south from Mochriesinch, on the south side of Greengairs. This ironstone is 15 in. thick in alternating hard and soft beds, all showing perfect "cone-in-cone" structure; a strong slaty blaes occurs both above and below it. There is no record of its having been worked. This ironstone seems to be rather far above the Virtuewell Coal to be correlated with the Roughband, but is here grouped along with it for convenience of description. It may be added that in certain areas where the Virtuewell Coal has an "oil-shale" above it, a thin ironstone is occasionally found between the two. In the Slammannan field, for example, where the Virtuewell has been wrought out, it showed:—

	Ft.	In.
OIL SHALE	0	6
IRONSTONE	0	2
COAL	2	6

In the Rawyards-Clarkston field again, to the east of Airdrie, the same association has been recorded. The section of the old workings

* Cf. "Econ. Geol. Central Coalfield, Area VIII," 1917, p. 43.

† Cf. "Econ. Geol. Central Coalfield, Area V," 1916, p. 95.

‡ *Ibid.*, p. 114.

at Mountcow, Blackridge and Turdees showed, for example, in the southern part of the field:—

			Ft.	In.
Sandstone	.	.	1	2
Black blaes	.	.	0	1½
SHALE	.	.	0	7
IRONSTONE	.	.	0	2
Black blaes	.	.	0	1½
COAL	.	.	2	2

In the Shotts-Fauldhouse coalfield the Roughband Ironstone is represented generally by a few thin clayband ribs or by scattered clayband balls, and has little or no economic value. Here and there a rib of 5, 6 or even $10\frac{1}{2}$ in. may be recorded (*e.g.* at West Benhar, Lanark, 9 S.E.) lying a few feet above the Virtuewell Coal.

The Soft Ironstone.—This seam is a poor ironstone of purely local occurrence, being confined to a strip, at no place exceeding 200 yds. in width, that stretches from Rawyards in a N.N.E. direction to Greengairs. The thickness in the centre of the strip was about 20 in., and the seam where worked lay about 5 ft. below the Airdrie Blackband. In Dykehead No. 1 bore, 2250 ft. W.S.W. of Whiterigg No. 1 Pit (Lanark, 8 N.W.), there are three thin seams of ironstone between $7\frac{1}{2}$ and $8\frac{1}{2}$ ft. below the waste of the Blackband, but none of these exceeds, 2 in. In another bore, situated 2750 ft. W. by S. of the same pit the Soft Ironstone is given as 10 in. thick, and its depth below the Blackband as 15 ft.*

Airdrie Blackband.—To this seam the Scottish iron industry owed a great deal of its early prosperity. It was discovered in the first years (see p. 8) of the nineteenth century, but did not come into general use until about 1830. From that date onwards until it became exhausted about 1875, it was greatly sought after and extensively worked, and supplied material to many of the Scottish blast furnaces.

The seam occurs over an irregularly-shaped area extending from Carnbroe in a north-easterly direction to Greengairs, a distance of about 6 miles. The breadth of this area from north-west to south-east is approximately 2 miles. This strip of country has Airdrie for its centre, and includes a large number of old collieries at which the ironstone was raised. Elsewhere the seam is represented by a coal, the Blackband Coal. On account of the lapse of time since the seam was worked, it is difficult to obtain accurate information regarding the thickness and nature of the ironstone in different localities. It was best developed in the Airdrie district when it seems to have averaged 14 in. Craig,† writing in 1839 or shortly before that, refers to it as follows—"Mushet's or Monkland Blackband lies 16 fms. under the Splint Coal. It is of very superior quality, measures generally from 14 to 18 in. thick, and occupies an area of 9 or 10 sq. miles in the neighbourhood of Airdrie." The writer of the account of Old Monkland Parish in the "New Statistical Account

* Prentice, "Mineral Seams of New Monkland," *Trans. Inst. Min. Eng.*, vol. xii., 1896, p. 442.

† "The Carboniferous Formation of the Lower Ward of Lanarkshire," *Trans. Highland and Agric. Soc.*, Second Series, vol. vi., 1839, p. 348.

of Scotland" * mentions a number of pits working the Airdrie Blackband, and states that it is "the great staple commodity for the supply of the iron market." Even in those early days the extent of the seam was very accurately known, † and Grossart, ‡ writing in 1868, was able to say that the Airdrie Blackband "is now nearly all worked out." The general section of the seam at Palacecraig and Faskine (Lanark, 8 S.W.) was:—

	Ft.	In.
Blaes		
COAL	0	7
Soft blaes	1	0
BLACKBAND	0	9
DARK SLATE	0	6
COAL	0	1

At Whifflet, Cairnhill and Greenwood it was 18 in. thick, but thinned out westwards towards Drumpellier, Langloan and Old Monkland. On the edges of the workable area the seam is represented by thin irony ribs above a coal. Thus at the Tunnel Pit, Drumpellier (Lanark, 7 S.E.), the section was:—

	In.
IRONSTONE	1
Blaes and IRONSTONE BALLS	8
IRONSTONE	1
Dark Blaes	6
IRONSTONE, not regular	1½
COAL	3

In the Rawyards-Clarkston district the seam was also long and intensively wrought, but few details are now available. East of Ballochney (Lanark, 8 N.E.) the blackband thinned away, and the following section at this locality may be taken as representative of the easterly limits of profitable working:—

	In.
Shaly Blaes	7½
BLACKBAND	4½
COAL	7
Coaly Blaes	6
COAL	4
Fireclay	3

At Gartness Pits No. 1 and 2, a little over three-quarters of a mile south of Clarkston, the seam is represented by three thin leaves of coal. South of Greengairs (Lanark, 3 S.E.) the Airdrie Blackband was largely wrought but varied a good deal in thickness. To the south of High Riggend it was 12 to 14 in. thick, but under Brownrigg degenerated to a coal streak, and to the west of the Avonhead Pits was only 2½ in. thick. Among the most recent workings in the seam appear to have been those at Dryflat (a little S.W. of Glen Mavis) and at No. 4 Pit Stand near High Riggend. The former were abandoned in 1875, the latter in 1879, and the sections were as follows:—

Dryflat.

Stand No. 4.

		Ft.	In.
Blaes	CRAW COAL	0	5
BLACKBAND, 6 in.	BLACKBAND	10 in. to	1
Blaes	COAL, etc.	10 in. to	1
	Sandstone pavement		

* Vol. vi., 1845, pp. 647-8.

† *Loc. cit.*

‡ *Trans. Geol. Soc. Glasgow*, vol. iii. 1868, p. 103.

Additional information regarding this seam will be found in a paper entitled "The Mineral Seams of New Monkland," contributed by Mr. James Prentice to the *Transactions of the Institute of Mining Engineers* (vol. xii., 1896, pp. 440-2).* In this paper the following analysis of the raw ironstone in its best state is given:—

	Per cent.
Protoxide of iron	48·25
Carbonic acid	32·91
Carbon	12·90
Combined water	3·74
Phosphoric acid	0·94
Lime	0·56
Silica	0·40
Magnesia	0·30

This analysis gives a metallic iron percentage of 37·5. The same seam was also wrought as a blackband to the west of Newarthill (Lanark, 12 N.E.). A bore in this locality records 15 in. of blackband above 27 in. of coal and shale. Where the ironstone was worked in the Legbrannock field to the south of Craighill it was 6 to 11 in. thick. West of Legbrannock its place is taken by a coal, i.e. at Holytown and northwards as far as the east-and-west Calderbank fault. Locally here a thin rib of blackband occurs close above the coal, but even this soon dies away. In the Thankerton field, for example, we find the following section (Lanark, 12 N.W.):—

	Ft.	In.
IRONSTONE RIB	0	2
Faky blaes	0	4
COAL	0	3
BLACKBAND	0	½
COAL	0	8
Coaly blaes	0	1
COAL	0	3
Fireclay	0	4
COAL	1	6

The only other locality where a blackband ironstone is found at this horizon is in the Quarter district to the south of Hamilton.

Quarter Blackband.—The seam here lies 12 fms. below the Splint Coal, and had been proved in bores by 1854. It was wrought only in the eastern part of the Quarter field over an area of approximately 230 acres according to the old working plans (Lanark, 17 S.E., 18 S.W.). It thinned to 3 or 4 in. in the direction of Fairholm, and towards the west became very coaly. As recently proved in No. 7 Pit, Quarter, it is represented by 16½ in. of inferior coal. Where worked it averaged 8 in. The workings ceased in 1869, and probably began about the time of commencement of the Quarter Ironworks in 1865.

Musselband Ironstone and Coal.—This coal is of little value over the greater part of the Central Coalfield, but has been worked to some extent in the district between Rawyards and Greengairs. The overlying "musselband," however, has attracted attention as a useful index-mark in bores. The "mussels" are found sometimes in the blaes overlying the coal and sometimes in the thin limy ironstone ribs or nodules which accompany them. These ribs have not been regarded in the Rawyards field as of any value as iron ores, nor are they known anywhere to occur in workable thickness. Even

* See also Mushet, "Papers on Iron and Steel," 1840, pp. 120-9.

though the coal is absent the Musselband horizon can generally be readily recognised and traced from district to district. Sometimes the "mussels" are so crowded as to form bands of "marble" several inches thick* (Coatbridge). Two sections of this horizon may be given by way of illustrating its development.

- (1) South side of Legbrannock Burn, 300 yds. S.W. of Legbrannock House (Lanark, 12 N.W.).
- (2) Section formerly seen in quarry near Rochsolloch Brick Works, Coatbridge.

	(1)	Ft.	In.	
Blaes and IRONSTONE ribs		3	0	
Parrotty musselband		0	2	
Musselband (compact ferruginous limestone)	4 in. to	0	5	
Blaes with scattered "mussels"		0	6	
IRONSTONE rib with "mussels"	2 in. to	0	3	
Parrotty blaes	0 in. to	0	1	
Blaes and IRONSTONE ribs		2	0	
	(2)	Fms.	Ft.	In.
Blaes with sandstone courses and thin CLAYBAND ribs		2	4	0
MUSSELBAND IRONSTONE	1 in. to	0	0	2
Blaes		0	2	6
MUSSELBAND IRONSTONE	1 in. to	0	0	3
Blaes		0	0	6
Parrotty blaes with "mussels"		0	0	2
Shelly marble with cone-in-cone structure	2 in. to	0	0	10
Parrotty blaes with "mussels."		0	0	6

Palacecraig Blackband.—Like the Airdrie Blackband, this seam is only of historic interest.† It is a local ironstone developed in the neighbourhood of Whifflet, and lying some 24 fms. above the Ell Coal, or 6 to 7 above the Upper Coal. It was also known as the Upper Blackband. Craig,‡ writing shortly before 1839, says:—"The Upper Blackband occurs at Palacecraig, being the only place where it has been found worth working. It is of inferior quality to Mushet's Band" (*i.e.* the Airdrie Blackband) "and is now no longer wrought." It was about 12 in. thick on an average, locally reaching 18 in. It was wrought to the south of the River Calder between Calder Iron Works and Faskine on the lands of Palacecraig, Faskine and Woodhall. In the Palacecraig workings it showed:—

	Ft.	In.
Blaes		
BLACKBAND	1	0
Blaes	rather over	2
COAL	1	1

At the March Pit it is recorded as having been 19 in. thick and lying $7\frac{2}{3}$ fms. above the Upper Coal. It was worked southwards nearly to Orchard Farm, but rapidly deteriorated. At Crow Pit, about half a mile W.S.W. of Woodhall House, the Palacecraig Iron-stone is represented by:—

Shale and IRONSTONE ribs		2 ft.
COAL		1 ft.

* See "Econ. Geol. Central Coalfield, Area V.," *Mem. Geol. Surv.*, 1917, p. 57.

† This was the first blackband discovered by Mushet in 1801 in the River Calder, "a little above Cairnhill Old Mill." See his "Papers on Iron and Steel," 1840, pp. 121-2, where an analysis of the stone is given.

‡ *Trans. Highland and Agric. Soc.*, Second Series, vol. vi., 1839, p. 348.

ESTIMATED RESERVES IN CENTRAL COALFIELD.

Name of Seam.	For Description see Page	Area in Acres.	Reserves in Tons.	
			Probable.	Possible.
(1) Coal Measures.				
Clayband balls above Upper Drumgray Coal	124	...	...	See Note 1
Clayband ribs above Mill Coal	121	...	...	"
Ball Ironstone (above Ball Coal)	118	...	...	"
Clayband ribs above Colinburn Coal	117	...	...	"
Armadale Slatvband Ironstone	116	...	Small	See Note 2
(2) Millstone Grit.				
Bowhousebog Ironstone (Blackband)	109	80	249,000	See Note 3
Curdly Ironstone (Clayband)	105	1	4,200	See Note 3
(3) Limestone Coal Group.				
Cadder Main Ironstone (= Possil Upper Ironstone)	86	...	...	See Note 4
No. 3 Blackband, Kilsyth	96	...	...	See Note 5
Blackband above Main Coal, Giffnock	90	...	Small	See Note 6
Clayband above Jewel Coal, Giffnock	90	...	...	See Note 1
Lower Coal and Ironstone at Giffnock	89	...	...	See Note 7
Claybands of Black Metals				
(a) Kilsyth and district	94	14,640	...	65,880,000
(b) N.W. Glasgow district	80	9,600	...	34,560,000
(c) N.E. Glasgow "	81	10,240	5,000,000	38,000,000
(d) Denny and Plean "	98	16,260	4,860,000	73,750,000
Lower Garscadden or Banton Blackband	91	...	...	See Note 8
Garibaldi Claybands				
(a) Kilsyth and district	91	6,710	...	24,156,000
(b) Glasgow and district	75	...	...	See Note 9
Johnstone Claybands	70	13,750	7,480,000	69,360,000
(4) Lower Limestone Group.				
Raesgill Claybands	64	130	780,000	See Note 10
Househill Claybands	61	5,120	230,000	36,864,000
Totals			18,603,200	342,570,000

Notes on above Table.

Note 1. At present being worked; merely thin ribs or nodular layers above a coal; most important is Ball Ironstone; no estimate of reserves attempted.

Note 2. Formerly worked; a purely local seam; reserves must be small. This is also true of various other blackbands, e.g. Lower Ironstone of Bo'ness (see pp. 101-2), Batchie and 14-in. of Cadder (see pp. 85 and 88), etc.

Note 3. Too variable and impersistent to estimate.

Note 4. Consists of both a blackband and a clayband rib overlying a coal. No estimate attempted.

Note 5. Probable reserves cannot be considerable. Small areas of workable stone occur here and there, but the seam is too impersistent for estimation. Only worked at Dumbreck Colliery at present.

Note 6. Thin rib (0 to 6 in.) above a workable coal.

Note 7. Available data insufficient.

Note 8. No estimate of possible reserves attempted; data insufficient. Small workable areas here and there.

Note 9. Only locally as much as 12 in.

Note 10. There are also considerable "possible" reserves, but the available data are insufficient to enable us to frame an estimate of these.

CHAPTER IV.

BEDDED ORES OF CARBONIFEROUS AGE (*continued*).

FIFESHIRE.

INTRODUCTION.

FIFESHIRE is less favoured than the Central and Western coalfields as regards the extent and value of its iron-ore deposits. Even when at the height of its development the Fife iron industry never contributed more than a small fraction of the total Scottish output,* quite out of keeping with the size of the mineral-producing area of the county. The earliest systematic iron-ore raising of which we have definite records, is that of the Pittirrane Mine, Dunfermline, where the clay-band ironstone roof of the Two-foot Coal was worked for smelting at the Carron Ironworks, from the year 1768.† Later, the Pittencraeff seam was worked on the Elgin Estate, Dunfermline, and during the first half of the last century several mines were opened in the Oakley and Saline districts of the West of Fife by the Forth Iron Company, which also for a time worked ironstone in the Cowdenbeath and Lochgelly districts. Furnaces were erected at Oakley (Forth Iron Works) and at Lochgelly and Lumphinnans, and were in blast until 1875, since when the ironstone wrought in Fife has been smelted in the various iron works of the Central Coalfield. After the Forth Iron Company and the Lochgelly Iron Company ceased operations the seat of iron-ore raising continued to be in the Oakley district, apart from the ironstones worked in conjunction with coal by various coal companies. The Oakley field changed hands several times, and was finally taken over by the Coltness Company, who raised ironstone there from 1883 till 1907.

The Mineral Statistics show remarkable fluctuations in the output of Fife during the last forty years. The output sank several times to a few hundred tons, and rose to 30,000 tons and more during the early years of the present century. For the last few years the output has been negligible, being derived entirely from ironstone roofs and intercalated bands in coal seams.

There is not a great amount of literature dealing with the iron-stones of Fife. Passing references are found in the "Statistical Accounts of Scotland,"‡ in D. Landale's "Report on the Geology of

* Maximum output of ore in period 1895–1915 was 39,224 tons in 1903, equal to 4·6 per cent. of whole Scottish output. Minimum output for same period was 1265 tons in 1912, equal to 2·2 per cent. of whole.

† See Mushet, "Papers on Iron and Steel," 1840, p. 117.

‡ "Statistical Account of Scotland" (Sir John Sinclair), 1791–8; "New Statistical Account," 1834–45.

the East of Fife Coalfield,"* in P. Chalmers' "Mineralogical and Geological Report on the Dunfermline Coalfield,"† in the two Geological Survey Memoirs on Fifeshire,‡ and in Mr. R. W. Dron's "Coalfields of Scotland" (1902).

The Geological Survey "Memoir on the Geology of Eastern Fife" mentions the Denhead-Lumbo mine, near St. Andrews, and the "Memoir on the Geology of Central and Western Fife" gives the following list (pp. 202-203):—

- Lochgelly and Lumphinnans.
- Hill of Beath and Dalbeath.
- Halbeath Colliery.
- Kinglassie Coal Field.
- Tillybreck Pits.
- Kilmux Colliery.

The ironstones of Fife include both blackbands and claybands. They occur in the Coal Measures and in the Calciferous Sandstone Series, but it is in the Limestone Coal Group of the Carboniferous Limestone Series that they are most developed. The Millstone Grit of Fife does not contain any ironstones of value, though one was worked in the Millstone Grit of Dollar (at Vicar's Bridge), just beyond the north-western boundary of the county. The ironstones of the Coal Measures and of the Calciferous Sandstone are so few that their positions can easily be described without giving a stratigraphical account of these two series. As regards the Carboniferous Limestone there has been in the past a good deal of confusion in the names and correlation of the seams, so that the modern reading of the sequence, as given in Fig. 12, may be of use in showing the nomenclature adopted.

CALCIFEROUS SANDSTONE SERIES.

This division of the Fifeshire Lower Carboniferous is remarkable for the number of thin ironstone bands and layers of nodules that recur at frequent intervals. Mr. Kirkby's section quoted on pp. 77-99 of the Geological Survey "Memoir on the Geology of Eastern Fife" illustrates this forcibly. With few exceptions these ironstones are of the clayband variety, and individually too thin to be workable, though were they added together they would make up a large reserve. They have never been worked systematically, but it is interesting to note that given certain economic conditions they are not useless. Thus, from the "New Statistical Account of Scotland,"§ we learn that "about the year 1845 the thin bands and septaria of clay ironstone were frequently gathered by the shore of the Anstruther and Pittenweem parishes, as washed out from the disintegrated strata, and sold at from 9s. to 12s. for 24 cwt., and carried to Newcastle." In the St. Andrews district the same materials were sometimes collected and sent to the Carron Iron Works.||

Few blackband ironstones of Calciferous Sandstone age deserve

* *Trans. Highland and Agric. Soc.*, Second Series, vol. xi., 1837.

† *Trans. Highland and Agric. Soc.*, Second Series, vol. xiii., 1841, p. 298.

‡ "Geology of Central and West Fife and Kinross," 1900; "Geology of East Fife," 1902, *Mem. Geol. Surv.*

§ Vol. ix., 1845, p. 615.

|| *Ibid.*, p. 455.

(Continued.)

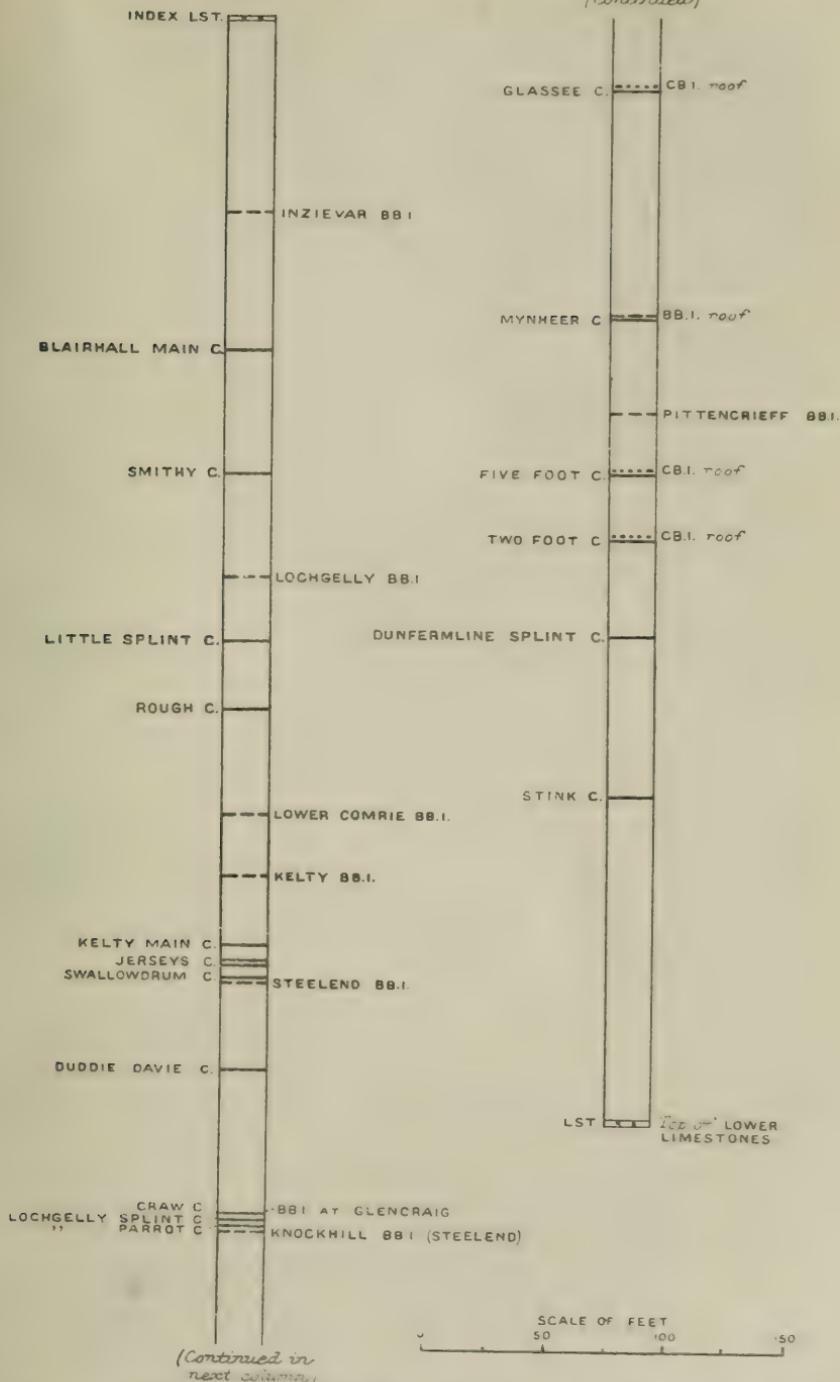


FIG. 12.—General Succession of the Coals and Ironstones in the Limestone Coal Group of Western and Central Fife.

C. = Coal.

CB.I. = Clayband Ironstone.

BBI. = Blackband Ironstone.

LST. = Limestone.

any notice. One occurs fairly low down in the sequence of the East of Fife Calciferous Sandstone, at Muiredge, north of Kilrenny (Fife, 22 N.E.). It is nowhere exposed, and its existence is known only from the fact of its association with the thin oil shale, which was worked at Muiredge and distilled near West Pitcorthie before the year 1873. To Mr. J. Gemmell we are indebted for the following section of the working face, which is no longer visible :—

					Ft.	In.
Limestone roof						
Blaes	:	:	:	:	0	6
Limy Blaes	:	:	:	:	0	3
OIL SHALE	:	:	:	:	10 in. to 1	1
Limestone fakes					2	0
BROWN IRON LIMESTONE					5 in. to 0	6
BLACKBAND IRONSTONE					0	5
IRONY PARROT COAL					0	9
Daugh holing					0	3
Coarse fireclay with hard balls					1 ft. 3 in. to 2	0
Foul coal					0	7

The Ironstone was separated from the rest of the seam and sent to the Lochgelly Ironworks, according to information supplied by Mr. Graham Yooll of the Sandhills Company.

As an ironstone of that thickness could not, under present conditions, be worked by itself, the possibility of this blackband at Muiredge being made use of would depend entirely on the concurrent working of the oil shale. The extent of the field cannot be determined, since no borings to the dip are known to reach this position. A bore 1100 ft. N.N.E. from the old pit, along the strike, recorded "hard limestone" at the horizon of the ironstone.

Another blackband of Calciferous Sandstone age is represented by the stratum numbered 188 in Mr. Kirkby's section already referred to. It crops on the shore immediately below the Pittenweem Gas Works, but where now exposed the seam is not wholly blackband: it passes into coal, and its thickness is less than when it was recorded by Mr. Kirkby, who estimated it at 2 ft. The dip is very high, being 55° and more.

LOWER LIMESTONE GROUP.

Ironstone occurs within the Lower Limestone Group, but is proved of economic importance in one district only, namely, in the Lumbo-Denhead area, S.W. of St. Andrews.

Lumbo-Denhead Field.

Maps, 1-in. Ordnance and Geological, 49; 6-in. Fifeshire, 12 N.W., S.W.

The ironstone is a blackband, the stratigraphical position of which lies between the basal limestone of the Lower Limestone Series and a limestone known locally as the Five-foot Limestone.

The field is a syncline stretching from Denhead across Mount Melville to Lumbo. The strata are generally very steep, the angle of dip often reaching 40°. At Denhead the dip is 20° to 25°. The ironstone was worked as far back as the first half of last century in the area to the south-east of Denhead, where a number of old

shafts show that the stone was extensively raised. How much remains among the workings is not ascertained.

The other portion of the field where it was mined lies south and west of Lumbo. The working stopped some 300 yds. west of Lumbo on account of a fault or dyke.

The position of the ironstone should clearly be found at the southern end of the Denhead field, that is, between Cassindonald and the most southerly of the old Denhead shafts. As the map shows no records of the sites of any old shafts, there is possibly an unworked field several hundred yards long, the crop of which could be ascertained by shallow borings. Old information shows that the ironstone was at one time seen cropping within the angle of the main road and the road leading to Denhead, three-quarters of a mile W.N.W. of Mount Melville. The crop would thence strike eastward to join with the crop at Lumbo, and the intervening space—a mile in length—could be proved by shallow borings. Should the ironstone be found of satisfactory thickness and quality there would be an extensive field, to which the main objection might be the steepness of the strata (up to 40°). There is no information regarding the opposite side of the basin, namely, south of Mount Melville.

The ironstone proper occurs in connection with coal, sufficiently abundant to furnish the quantity required for calcination.

According to the Geological Survey Memoir on East Fifeshire, p. 174, the composition of the seam at Lumbo was:—

	Ft.	In.
Shale		
PARROT COAL	0	5
COALY SHALE and coal streaks (Rums)	1	1
BROWN STONE (IRONSTONE)	5 in. to	0
COAL (CHERRY)	1	6
Shale		

It is also reported to have reached 1 ft. 8 in. in thickness. Further south on the Mount Melville estate, close to the march with Feddinch, the seam consisted of:—

	Ft.	In.
Fireclay		
PARROT COAL	0	5
COALY SHALE (Rums)	1	0
BROWN STONE (IRONSTONE)	1	8
Clay		

The outcrop of the ironstone was exposed during drain-cutting operations in March 1918, 1500 ft. due east of Denhead, but the seam was much disturbed, owing presumably to glacial action, so that measurements could not be taken. The stone appears, however, to be of good quality.

The railway station at Mount Melville is within a radius of 2 miles of the most distant parts of the field.

It is estimated that between four and five hundred thousand tons may be available as reserves, not counting the unknown area south of Mount Melville.

It is so far not proved whether the Denhead Ironstone extends beyond the limits of the original field just described, but there is a likelihood that it may do so in the district to the south, in the

direction of the strike. According to Mr. R. W. Dron* a bore was put down in 1859 on the lands of Cassingray [6-in. Sheets Fife, 15 S.W., 21 N.E., 22 N.W.], just beyond the outcrop of the Largoward Splint Coal. At a depth of 62 fms. a blackband ironstone resting on 1 ft. 9 in. of hard coal was met with. At that depth from the Largoward Splint Coal the blackband horizon should be somewhere within the Lower Limestone Group, and may therefore possibly represent the Denhead Blackband. It is to be hoped that further systematic boring will some day be made in this district.

Ironstone has been met with in the Lower Limestones of the west of Fife, but has never been worked, and owing to the infrequency of boring operations through these strata it is not known whether there are any deposits comparable with that of Denhead. Mr. H. Rowan of the Fife Coal Company has kindly supplied information to the effect that a seam of blackband ironstone 9 in. thick was exposed a few years ago in a temporary excavation one-sixth of a mile due east of Lochornie (Fife, 34 N.W.).

Another record of ironstone within the Lower Limestones is that given in the journal of the Elgin Bleachfield bore, published in the Geological Survey Memoir on Central and Western Fife, p. 49. The seam was noted as iron parrot coal or blackband ironstone, 1 ft. thick, at a depth of 51 fms., or 16 fms. below the thickest limestone of the series, which probably corresponds with the Charlestown Limestone.

LIMESTONE COAL GROUP.

In Fife as in Central Scotland the strata between the Index Limestone and the Lower Limestones are the chief repository of the Lower Carboniferous coals, and include also the principal ironstone seams. These ironstones are mainly of the blackband variety. Clayband is less abundant and of much less economic importance than in the corresponding strata of the Central Coalfield.

The strata between the Dunfermline Splint—the lowest workable coal of Western Fife—and the top of the Lower Limestones, contain only thin insignificant ironstones.

The lowest seam of the series to have been worked is a thin ironstone which sometimes occurs above the *Two-foot Coal* of the West of Fife. The "Statistical Account"† records that this ironstone consisted of two bands, the uppermost 4 in. and the lowermost $2\frac{1}{2}$ in. thick, which were wrought by the Carron Company from 1771 ‡ at the Pitfirrane mines, which were situated west of the old Urquhart and Pittencrieff mines, Dunfermline. There are no records that this seam was ever worked elsewhere.

A clayband ironstone very often constitutes the roof of the *Five-foot Coal* in Central and Western Fife. In the Beath district it used to be worked together with the coal, and its thickness reached 8 in. As the workings advanced the stone was found to deteriorate and thin out, and it is no longer worked in the Beath district.

At the Lethans Pits, near Saline (Fife, 33 N.E.), this same iron-

* "The Coal Fields of Scotland," 1902, p. 302.

† "Statistical Account of Scotland," vol. xiii., 1794, pp. 469, 471.

‡ In 1768 according to Mushet. See pp. 7 and 135.

stone roof is from 1 to 3 in. thick, and rather calcareous in character. It is at present being worked, and the estimated reserves in this field are about 77,000 tons.

The next ironstone horizon is the *Pittencriff or Elgin Blackband*. It is of interest not so much owing to the fact that it has been worked to a slight extent, as on account of its often forming a stratigraphical index-mark for the Five-foot Coal in boring operations. The seam is extremely variable in character and generally tends to pass into a coal. It must have been known and worked at remote periods, since the type district of Pittencriff was the earliest worked coal basin in Fife. The Pittencriff and Urquhart Coal Pits are spoken of as "nearly exhausted" in the old "Statistical Account,"* consequently few details are available concerning these. For information regarding the blackband here and in neighbouring areas we are indebted to Mr. D. Archibald, of Messrs. Thos. Stewart & Co., who states that at the old Pittencriff workings the blackband was about 6 in. thick. At the Balmule Pits, Wellwood Colliery, the ironstone was 6 in. thick, with 4 in. of coal, and was worked. In the Tom Pit, Wellwood Colliery, there was 6 in. of ironstone and 6 in. of coal. At Lassodie Colliery the general section as measured by Mr. Archibald is:—

Roof, dark blue blaes	12 to 18 in.
BLACKBAND IRONSTONE	3 to 4 "
Blue blaes	3 to 6 "
COAL	9 to 12 "
Grey blaes	6 "
Dark freestone bands	2 to 3 ft.

To the east of Dunfermline the seam is apparently not a workable subject: it is recorded more often as a coal than as an ironstone, and where ironstone is present it is seldom of the thickness it attains in the type district.

Three boring records of the years 1853–4, of source unknown, show ironstone near Remiltoun, S.E. of Oakley (Fife, 38 N.W.), at a short distance from the surface. These borings are too shallow to permit of interpretation of the positions, but from other evidence it is quite likely that the ironstone is in the Pittencriff position. As the borings were probably done by chisel, full reliance cannot be given to the thicknesses recorded, which are 9 in., 15 in., and 2 ft. 3 in. respectively. However, they show that the ground near Remiltoun is worth further investigation. Southwards, near Torryburn, and again in the Blairhall boring and at Valleyfield, the seam is very poorly represented.

Information recently acquired by the Oakley Collieries Company, and kindly communicated by Mr. N. Wilkie, show that the ground north of Oakley does not contain any workable development of the Pittencriff Ironstone, as is also the case at Steelend, still further north. It is possible that one of the ironstones formerly worked at South Lethans (Fife, 33 N.E.) was on this horizon, though this could not be ascertained with certainty.†

The *Mynehead Coal*, which is a constant seam over large parts of

* Vol. xiii., 1794, p. 471.

† Chalmers' "Mineralogical and Geological Report on the Dunfermline Coalfield," *Trans. Highland and Agric. Soc.*, Second Series, vol. xiii., 1841, p. 327.

the central and western Fife coalfield, often possesses an ironstone roof. It is in the Lochgelly field (Fife, 35 N.W.) that it is thickest and most persistently present. The stone is in this district a black-band varying in thickness from 4 to 6 in. The Lochgelly Iron and Coal Co. have for some years past taken it out together with its underlying coal from the Lady Helen Pit, Dundonald Colliery, and a sample analysed in 1914 gave the following results, kindly communicated by the company:—

	In Sample as Received.	In Calcined Sample. Per cent.
Protoxide of iron	41.37	...
Peroxide of iron	1.18	78.16
Bisulphide of iron	1.28	...
Oxide of manganese	0.89	1.57
Lime	4.53	7.38
Magnesia	4.00	6.52
Alumina	0.37	0.61
Silica	0.48	0.78
Titanic acid	0.02	0.02
Sulphuric acid	0.30	1.89
Phosphoric acid	1.87	3.05
Arsenic acid	0.02	0.02
Carbonic acid	31.34	
Coaly matter	8.25	
Water	4.10	
	100	100
Iron	33.59	54.71
Manganese	0.69	1.12
Sulphur	0.81	0.76
Phosphorus	0.82	1.33
Arsenic	0.01	0.01
Loss by calcination	38.60	

The above analysis shows a better stone than is the case in other pits of the Lochgelly field. For instance, a sample from Jenny Gray Pit gave:—

	In Sample as Received.	In Calcined Sample. Per cent.
Iron	14.83	22.74
Manganese	0.28	0.44
Sulphur	0.163	0.108
Phosphorus	0.45	0.69
Arsenic	0.013	0.021
Loss on calcination	34.79	

The analysis of a calcined sample from the Dora Pit was:—

	Per cent.
Iron	25.6
Insoluble	32.4
Sulphur	0.236
Phosphorus	1.082

Calcined samples from the Arthur, Mary, and Nellie Pits yielded:—

Iron	from 24.50 to 27.40 per cent.
Insoluble	from 17.10 to 26.50 "
Sulphur	from 0.110 to 0.92 "
Phosphorus	from 0.676 to 0.980 "

Mr. H. Rowan of the Fife Coal Company states that in the neighbouring fields of Donibristle, Cowdenbeath and Kelty the stone is not a workable subject. Considering the seam where it is at its best, namely, in the area worked by the Lady Helen Pit, there is a proved reserve of some 80,000 tons, with doubtless more that has not been definitely ascertained.

At various localities an ironstone, generally thin, occurs above the next important coal—the *Glassee*—sometimes close enough to it to constitute its roof. Except at one locality the information obtained up to the present shows it to be quite negligible, the exception being the old Tom Pit, where the Glassee Coal was 17 in. thick with a 10-in. roof of inferior ironstone, but it is not known how far this unusually thick development extends laterally. That it is local seems to be established by the fact that the section of the disused adjacent Victoria Pit shows no ironstone above the Glassee Coal, and neither does that of the old Wallsend Pit. In the places at present accessible at Wellwood Colliery the thickness is, according to Mr. D. Archibald, from 3 to 4 in., and at Lassodie from 2 to 3 in.

A blackband which has occasionally been recorded in connection with the *Lochgelly Parrot Coal* may be mentioned here as an illustration of the tendency often exhibited by parrot coals to pass into or contain blackband ironstone. In the case of this parrot the few occurrences noted are purely local in character and of no economic value. The Geological Survey Memoir* refers to the blackband pavement of the Lochgelly Parrot in Donibristle Colliery, on information supplied in 1889 by Mr. Carlow of the Fife Coal Co., but more recent observations have shown it to have been sporadic, and the same applies to the ironstone recorded in the Lochgelly field general section,† where it is stated to occur between the Lochgelly Splint and the Parrot. In the Balfour Mains bore (Fife, 28 N.W.) the Lochgelly Parrot was pierced at 593 fms. from the surface, and included 5 in. of blackband. Another instance of the variability of this ironstone is shown in the section of the North Steelend mineral field of the Forth Iron Company (Fife, 33 N.E.); the 5 in. of ironstone recorded there below the Parrot is not represented in the fairly numerous borings put down of recent years through that position in the same area by the Wilsons & Clyde Coal Company.

A coal and parrot, which in the Steelend field occurs one or two fathoms below the Lochgelly Parrot, included, in the area east of Knock Hill, an ironstone which was worked by a small mine in the side of the hill. Owing to the high angle of the slope the available area must have been inconsiderable, and it is unlikely that any noteworthy reserves can be left. According to information supplied by Mr. J. Gemmell this ironstone at Knock Hill was from 8 to 11 in. thick, but like the lenticular seam mentioned above it is absent in the modern borings put down in the Steelend district.

It is possible that the two most westerly ironstone pits of the South Lethans Colliery worked that seam, which is believed to be exhausted, judging from the number of "wastes" met during the recent operations of the Wilsons & Clyde Coal Company.

The *Craw Coal*, which in the Glencraig field (Fife, 26 S.E.)

* "Geology of Central and Western Fife and Kinross," 1900, p. 108.

† *Ibid.*, p. 115.

immediately overlies the Lochgelly Splint Coal, is there replaced by a blackband ironstone, 8 in. thick, forming the roof of the coal. It is not systematically worked, but is taken out when there is a fall of roof. In this manner 300 tons were removed recently during a period of five months. Some 25,000 tons are expected to be available in the Glencairn Colliery, but as the blackband variation of the Craw Coal is met with again to the north, it is probable that the actual reserves of this ironstone will be much more considerable than it is possible to estimate at present.

Steelend (Saline) Ironstone (6-in. Sheet, Fife, 33 N.E.).—The small ironstone field of Steelend presents features of peculiar interest. Although the seam which was worked there reached a thickness exceeding any other recorded for the Fife ironstones, its lateral extent is remarkably small, and the field is limited to a restricted area partly concealed under the volcanic ash of Saline Hill.

The stratigraphical position of the ironstone has been misinterpreted in the published accounts of the geology of the district. In the Geological Survey Memoir* and elsewhere the ironstone horizon is placed above the Jersey and Main Coals and is correlated with the Lochgelly Ironstone, while its true position is much lower down in the series. The upper and principal seam is placed 19 fms. above No. 4 Coal of the Forth Iron Company's section—which is now correlated with the Lochgelly Splint. In another section, communicated by Mr. J. Gemmell, the Upper Ironstone is placed 30 fms. above the Lochgelly Splint, with 26 ft. of volcanic ash in the intervening strata. The position of the ironstone is thus probably on the horizon of the Swallowdrum Coal, as was long ago the view held by the late Mr. J. Thomson of Dunfermline. This is also supported by the fact that the Swallowdrum Coal often passes into cannel coal, and there is at least one record of this cannel containing a definite band of ironstone in the Dunfermline area.

The field lies under the south-eastern and eastern portion of Saline Hill, the creeps following the contour of the hill, a few hundred yards from the ash under which the seam dips. A number of old pits mark the direction of the crop from a point S.W. of East Sunnybraes to a point half-way between Saline Hill and Knock Hill. These workings are of such ancient date that little information could be obtained concerning them, beyond the fact that some were worked by the Forth Iron Company early last century, while one was worked more recently for the Calder Iron Works. This mine was situated at the northern end of the field, and the workings, which were quite small, were discontinued in 1873. The plan lodged with the Home Office gives the following details of the constitution of the seam:—

Fakes (irony)	.	.	.	6 in.
BLACKBAND IRONSTONE (sandy)	.	.	.	36 "
Blaes	.	.	.	9 "
BLACKBAND (wandering)	.	.	.	8 "

The workings extended just within the margin of the Saline Hill volcanic ash. It is evident that there must still be a considerable space between the working face of that mine and the central volcanic

* "The Geology of Central and Western Fife and Kinross," *Mem. Geol. Surv.*, 1900, p. 127

plug, as is demonstrated by the fact that a coal higher in the sequence was worked several hundred feet further in below the ash. There is thus a fair possibility of some reserves lying under the eastern corner of Saline Hill. It is not possible to estimate the amount as there are no borings through the Saline Hill ash, but the position might occupy some 150 acres between the margin of the ash and the plug of Easter Cairn.

Another ironstone has been recorded at a distance of 9 fms. below the seam just described. It is probably local in character, as it is not mentioned in the Forth Iron Company's section, and with the exception of a single record of a 2-in. ironstone, a thin coal occupies the position as met with in the recent Steelend borings.

To sum up the evidence obtained, it appears that in any attempt at proving the possible remaining reserves of the Steelend field, only the Upper Ironstone should be taken into account, and that in the area concealed under the volcanic ash of the eastern portion of Saline Hill.

The thin yellow stone parting which is so frequently a characteristic feature of the *Jersey Coal* attains an unusual thickness at Glencraig Colliery. In the portions of the seam worked during 1917–1918 the stone was found to reach 18 in., and as it contains 27·6 per cent. of metallic iron it is collected and sent to the iron works.

Kelty Ironstone.—In Central and Western Fife there is frequently found, a few fathoms above the Kelty Main Coal, a thin coal or parrot coal which at times passes into ironstone. Some confusion has arisen concerning the identification of this ironstone. The Geological Survey Memoir* correlates it with the Lochgelly Ironstone, but comparison of typical sections in the Kelty and the Lochgelly fields respectively shows that there are several ironstones between the Main Coal and the Index Limestone position, and that the Lochgelly Ironstone is much higher in the sequence. Mr. J. Gemmell has kindly summarised his reading of the Kelty sequence as follows:—

INDEX LIMESTONE						
Strata						6 fms.
BLAIRHALL IRONSTONE						
Strata						7 "
BLAIRHALL COAL						
Strata						26 "
IRONSTONE AND PARROT COAL						
Strata						29 "
KELTY IRONSTONE						
Strata						6 "
MAIN COAL OF KELTY						

This ironstone is generally so thin that it hardly deserves notice, but it is necessary to mention it here on account of the apparent importance given to it by the fact that it is represented by an outerop line on the published geological map (1-in. Sheet 40; 6-in. Fife, 30 S.E., Old Series), and that a pit was once sunk to it. That pit was noted during the original survey of the Kelty district, and was situated some three or four hundred yards S.E. of Oakfield, Kelty (Fife, 34 N.E.), and its depth is stated to have been 18 or 20 fms. No information could be obtained about it, and it may have been nothing

* "The Geology of Central and Western Fife and Kinross," Mem. Geol. Surv., 1900, p. 112.

more than a trial shaft. Mr. H. Rowan states that where met in modern shafts and borings in the Kelty district the seam is not workable.

In the light of information so far obtained, the thickest development recorded is 13 in. At the same time its variability is instanced by the fact that in the Glencraig boring the seam is entirely absent. It is represented merely by nodules in the Pitcairn boring, Lochgelly, and by a 2-in. rib in the Bowhill shaft section, Cardenden.

The horizon is recognisable in the extreme west of Fife—Oakley and Kinnedar districts—but does not include more than from 1 to 3 in. of ironstone, except in the Blairhall area, where the seam as recorded in the journal of the Blairhall diamond boring (Fife, 38 N.W.) consisted of: *—

	Ft.	In.
PARROT COAL (irony)	0	4
BLACKBAND IRONSTONE	0	6
PARROT COAL	0	4
COAL	1	8

In one of the Valleyfield borings, 1½ miles S. of Blairhall, the thickness of this blackband is 7 in., but there the ironstone is not accompanied by any coal, though in another bore in the vicinity a 5½-in. seam of ironstone, which may be the same, does rest on a coal.

Lower Comrie Ironstone.—The district of Oakley is of all the mineral fields of Fifeshire that which contains the greatest number of ironstone horizons. Reference to the published journal of the Blairhall bore,† cited above, will show no less than seven ironstones of 6 in. or more, of which two—possibly three—have been worked in the past, one of them extensively. Of these ironstones of appreciable thickness the seam to be considered now lies about 10 fms. above the ironstone taken to be the representative of the Kelty Blackband. It is "No. 3" Ironstone of the old Forth Iron Company's section, also known as "Lower Comrie" Ironstone, in contradistinction to the "Upper Comrie" Ironstone. The latter, which is also named No. 1 or Blairhall or Inzievar Ironstone, occurs considerably higher up in the sequence, close below the Index Limestone. As other ironstones are known in the intervening strata correlations and identifications are not always easy, and additional complication is introduced by the fact that at Blairhall the Limestone Coal group is unusually thick and contains numerous coals which are not represented in even closely adjacent areas. Also, this ironstone and the uppermost one are practically confined to the Oakley district as workable subjects.

The area has been the seat of mining activity for a long period, and as it has passed through several different hands, much of the older information is lost, but for communication of the evidence at present available thanks are due to Messrs. Russell and to Mr. N. Wilkie, of the Coltness Company and Oakley Collieries respectively, the present lessees of the greater part of the area.

The Lower Comrie Blackband has been met in borings and shafts from Blairhall (Fife, 38 N.W.), northwards to Blairsgreen

* "The Geology of Central and Western Fife and Kinross," *Mem. Geol. Surv.*, 1900, p. 271.

† *Ibid.*, pp. 268-73.

(Fife, 33 S.W.), and was worked between Topitlaw and Comrie Mains. The Forth Iron Company's section indicates a thickness of 10 in., and the plan shows that not more than 20 acres was worked.

In the field of the Blairhall Colliery, that is S.W. of the old Topitlaw workings, the seam was cut in bores and in shaft sinkings, and the analysis of the seam from one of the bores gave the following results:—

	Per cent.
Carbonate of iron	69·301
Iron pyrites	0·33
Manganese	trace
Carbonate of lime	3·37
Carbonate of magnesia	3·381
Alumina	3·167
Silica	1·45
Phosphoric acid	0·753
Loss on ignition, being—	
Organic matter and water	17·685
	<hr/>
	99·437
Iron	33·61
Sulphur	0·176
Phosphorus	0·329

The seam consisted—as cut in the deep Blairhall bore*—of 11½ in. of blackband, underlying 15 in. of parrot coal. It is evidently very variable in thickness; it is not recognisable south and south-west of Blairhall, while in two borings on either side of the old Topitlaw workings the seam appears only as an inconspicuous rib. This may be the reason why the workings were abandoned.

The seam has been met in five modern borings in the area around Blairsgreen, half-way between Oakley and Saline. The thickness was 6 in. in the Sunnyside boring, 7 in a few hundred feet due north of Blairsgreen, 13 in. in two borings about the same distance west and north-east of the same locality, and 15 in. in another boring due south of it. The stone from the bore last-mentioned was analysed and gave:—

	Per cent.
Loss on calcination	37·87
Metallic iron in raw	36·50
" " calced	58·74

Lastly, the seam was also cut in the shaft sinking of No. 3 Pit, Oakley Collieries, but no record was kept of its nature and thickness.

From the evidence as given above it follows that the Lower Comrie Blackband is known at intervals over a distance of some two miles in the direction of strike, and that at its maximum thickness it might prove a workable subject. Taking, for instance, the five borings around Blairsgreen as representing an average, they would indicate for that locality a possible reserve of some 600,000 tons, and there might, of course, be farther and larger reserves in the unproved ground in the direction of the dip, at considerable depths however.

Further evidence would be required to determine whether there are possible reserves to the dip, west of Topitlaw and at Blairhall.

An ironstone 6 in. thick was met in the Blairhall bore a short

* "The Geology of Central and Western Fife and Kinross," *Mem. Geol. Surv.*, 1900, p. 270.

distance above the *Ontake* or *Sour Milk Coal*. It seems to be purely local in its distribution.

Lochgelly Ironstone.—The Lochgelly Blackband Ironstone is one of the few seams to have been worked independently of coal-mining. The horizon is of considerable extent over Western and Central Fife, but varies considerably in thickness from place to place.

The seam is best known in the type-district of Lochgelly, which in a geological sense embraces the adjacent fields of Lumphinnans and Cowdenbeath. It lies there generally a few fathoms above the Little Splint Coal, and some 25 to 30 fms. above the Fourteen Foot Coal, in a set of arenaceous strata.

The Lochgelly Blackband possesses a peculiar character which gives it a place apart from that of the other ironstones of the Limestone Coal Group of Fife. Its peculiarity resides in its intimate association with a bituminous shale of the nature of oil shale, capable of distillation with a yield sometimes equal to that of some of the well-known oil shales. Experiments have been undertaken with the view of finding whether the oil contents of the seam might eventually justify its being worked in areas where the ironstone alone would be too thin to repay the cost of extraction. The proportion of shale is often larger than that of ironstone, but even where best developed the seam is below the average thickness of the proper oil shale seams of the Lothians. Regarded simply as an oil producer, it could not be a workable subject, though it might be if taken in conjunction with its iron contents. Some of the results of the experiments begun by the Lochgelly Iron & Coal Co. and by the Fife Coal Co. show that the percentage of oil varies within wide limits.*

An analysis of an average sample of shale 16 to 18 in. thick overlying the ironstone at the Eliza Pit, Lochgelly, gave the following results:—

	Per cent.
Fixed carbon	9·61}
Ash	44·77}
Vol., H ₂ O	44·08}
Moisture	1·54}
	<hr/>
	100·00
Sp. gr..	1·95
Iron in ash	39
Distillation by steam, 36 gallons of tar and oil per ton ; 23·2 lbs. of sulphate of ammonia per ton.	
	Per cent.
Iron	32·48
Silica	20·14
Coaly matter	10·74

The section of the seam as cut in the Moss-side Pit, Cowdenbeath, is different. It consists there of:—

	Ft.	In.
Blaes	0	5
IRONSTONE, mixed	1	0½
Blaes	0	3
IRONSTONE	0	2½

* Thirty-two gallons crude oil per ton is quoted in Iltyd T. Redwood's treatise : "Mineral Oils and their By-products," 1914, p. 40.

and the analysis of the whole gave—

	Per cent.
Iron	21·15
Silica	14·75
Alumina	6·28
Sulphur	0·72

Crude oil 13·26 gallons per ton of specific gravity 0·972 and setting point 82°.

Although information is lacking as regards the oil contents of the seam at all its occurrences, it appears fairly certain that more or less bituminous shale accompanies the ironstone over the greater part of the Lochgelly coalfield, that is, from the Beath district in the west to Cardenden in the east. Elsewhere, with possibly one exception, the seam is like other blackbands.

The thickest development of ironstone seems to have been where it was wrought in the old Lochgelly workings. The thickness varied from an average of 21 to 24 in. at the Easter Colquhally workings down to an average of 12 in. with 4 in. of "balls" at the Grainger Square workings, intermediate thicknesses being recorded in the workings south of the field. It is interesting to note that in the Eliza Pit shaft, a short distance east of Easter Colquhally, where the seam was well developed, it decreases to between 2 and 4 in., excluding the overlying shale referred to above.

The following analyses show its average composition in the type district:—

From the Dora Pit.

Raw Stone.		No. 1. Per cent.	No. 2. Per cent.
Loss on ignition	.	28·1	36·9
Moisture	.	1·5	3·3
Yield of calcined stone	.	70·4	59·8

Calcined Stone.

	Raw.	Calcined.
	Per cent.	Per cent.
Iron peroxide	55·43	57·57
Manganese peroxide	1·14	1·19
Insoluble	22·60	23·60
Alumina	8·42	8·26
Lime	2·41	2·01
Magnesia	7·96	5·07
Sulphuric acid	0·686	1·097
Phosphoric acid	1·043	0·673
Iron	38·8	40·3
Sulphur	0·274	0·439
Phosphorus	0·455	0·294

From Lady Helen Colliery.

	Raw. Per cent.	Calcined. Per cent.
Protoxide of iron	36·06	
Peroxide of iron	0·91	77·10
Bisulphide of iron	0·49	
Oxide of manganese	2·45	4·90
Lime	3·96	7·40
Magnesia	2·88	5·38
Alumina	0·19	0·36
Silica	0·33	0·62
Titanic acid	trace	trace
Sulphuric acid	0·16	0·98

	Raw.	Calcined.
	Per cent.	Per cent.
Phosphoric acid	1·73	3·24
Arsenic acid	0·01	0·02
Carbonic acid	28·32	
Coaly matter	16·61	
Water	5·90	
	—	—
	100·00	100·00
Iron	28·95	53·97
Manganese	1·88	3·52
Sulphur	0·033	0·39
Phosphorus	0·75	1·40
Arsenic	0·005	0·011
Loss on calcination	46·29	

Sample of full thickness (3½ in.) of Ironstone from the Eliza Pit.

	Per cent.
Iron, raw	33·60
" calcined	56·82
Yield on calcination	59·12

The distribution of the old Lochgelly workings illustrates very well the structural irregularities of the ground, due to the number of small troughs and arches which are cut by faults. The seam is thus constantly appearing and disappearing; this explains the lack of continuity of the workings, which occupy small detached areas around Lochgelly village. The total aggregate area of these old workings is not more than 200 acres; most of the extraction was done by pit shafts, and to a limited extent by opencast working, and took place from the year 1847 to the year 1875, when, with the exhaustion of the more shallow portions of the seam, operations became unprofitable.

The reserves left in the Lochgelly field will be found to the dip, that is, both westwards and eastwards from the old workings, and the position at least extends also northwards.

The stone is, however, not a workable subject over the greater part of its area. As already stated, it is only 3½ in. thick in the Eliza Pit, 500 ft east of the margin of the Easter Colquhoun workings, and still farther east, at the Minto Pit, it is not more than 3 in. thick. South of that area, towards Lochgelly and passing through Newfarm, there is an almost unproved field with two records of the seam, 20 and 19 in. thick respectively, shale included. It is estimated that the reserves included in this eastern area may amount to 1,400,000 tons.

North of the old Lochgelly workings, that is north of the River Ore, the seam is too thin to be taken into consideration, the thickness being only 1 in. at Pitcairn, and 4 in. at Glencraig. Some 400,000 tons might be expected between East Cartmore and the Fitty Burn. West of that locality again there is room for a larger field, but in the absence of information it would not be safe to estimate more than some 800,000 tons; where met again further west, at the eastern end of the Kelty Coalfield, the seam is too thin to work. It is likewise difficult to reckon the available reserves in the south-western area of the Lochgelly field, that is, in the Lumphanans and Cowdenbeath area, as from there also the seam

thins out in a westerly direction. These reserves are conjecturally estimated at about 200 acres, but the stone analysed from the Moss-side Pit, Cowdenbeath, is not of good quality (see above).

The details on which the above account of the Lochgelly field is based were communicated by Messrs. J. Paul and J. Sutherland, of the Lochgelly Iron and Coal Company.

The Lochgelly Ironstone is met again in the extreme west of the county, in the Oakley district, but, as stated previously, its reported occurrence in the Steelend (Saline) field is due to a mistaken reading of the sequence (see p. 144). The position is recognisable in the Kinnedar area (Fife, 33 S.W.) as insignificant thin ribs, and it is only in the Comrie-Oakley-Blairhall area (Fife, 38 N.W.) that it again attains a workable thickness. Owing to the great thickening of strata in that region, correlation of individual seams with the well-known seams of adjacent fields is not easy, but there is little doubt that the Lochgelly Blackband Ironstone corresponds with No. 2 Ironstone of the Forth Iron Company's section, which is the same as the "Success Blackband" of the Coltness Iron Company. Its position was 33 fms. below No. 1 (Upper Comrie) Ironstone in the Forth Company's Inzievar workings, and 29 fms. below No. 1 Ironstone in their Comrie workings. In the great Blairhall bore the distance is also 33 fms. Its thickness at Inzievar was 6 in., and at Comrie No. 4 Pit 9 in. Its section as cut in the Blairhall bore is as follows:—

IRONSTONE (BLACKBAND)	:	:	:	1 in.
Parrotty blaes	:	:	:	3 "
IRONSTONE (BLACKBAND)	:	:	:	5 "
Fakes	:	:	:	11 "
IRONSTONE (BLACKBAND)	:	:	:	7½ "
COAL	:	:	:	3 "

The two principal bands of the seam were analysed separately, and the results are quoted here by permission of the Coltness Company.

	5-in. Band.	7-in. Band.
	Per cent.	Per cent.
Carbonate of iron	81·735	66·23
Carbonate of manganese	1·43	2·25
Carbonate of lime	3·36	6·07
Carbonate of magnesia	4·93	5·48
Iron sulphide	0·157	0·198
Alumina	1·618	2·34
Silica	1·18	2·11
Phosphoric acid	0·656	1·28
Moisture	0·204	0·896
Coaly organic matter	4·75	13·146
Iron in calcined ore	60·52	54·20

It is not stated whether the reference to the Forth Iron Co.'s No. 4 Comrie Pit means that the ironstone was worked there, or that it merely indicates a record of measurement. At all events, workings, if any, are not indicated on the plan.

At Valleyfield, what may be the same ironstone is 5 in. thick, and this completes the information obtained about the Lochgelly Ironstone position in the West of Fife. With so few records to go upon no opinion can be expressed regarding the economic possibilities of the seam in this area.

An ironstone which occurs at Kilmux, on the eastern side of the central coalfield, may possibly be the same as the Lochgelly Blackband; but as this identification is not definitely proved, the ironstone is recorded below under a separate heading.

Kilmux Ironstone.—At Kilmux (Fife, 20 S.E.), about $1\frac{1}{2}$ miles N.E. of Kennoway, and 3 miles N.W. of Leven, there is a small coal-field—abandoned for many years—containing a workable ironstone. This field is separated from the main Limestone Coalfield of Central Fife by the Wemyss Coal Measures field, the underlying portions of which are not known except as regards the records of a single boring—the Balfour Mains Bore. The Kilmux field being thus isolated, the nomenclature of its seams is different from that of the districts considered in the preceding pages. Correlation of the seams is also further hindered by differences in the nature of the sedimentation, notably by the presence of volcanic ash. Therefore it is not possible to assign definitely the Kilmux Ironstone to any of the well-known seams reviewed so far, but, with reservations necessitated by the reasons just shown, it seems quite likely that this ironstone is on the position of the Lochgelly Blackband. The Kilmux Ironstone has been worked to a small extent at the Kilmux Mine, from the records of which the following details are taken. The ironstone lies from 2 to 3 fms. below a coal known locally as the Six-foot Coal, and the constitution of the seam in the workings was:—

	In.
Fakes	
FREE COAL	6
SHALE	4
PARROT COAL	7
BLACKBAND IRONSTONE	10
Blaes and Balls	

One and a half to 2 ft. is the thickness given in the Geological Survey Memoirs,* and the stone is described as good. The assumption on stratigraphical grounds that the Kilmux Ironstone is a representative of the Lochgelly Ironstone would be substantiated by the association with shale, which, as pointed out, is a peculiar feature of that ironstone.

The actual site of the Kilmux ironstone workings was between Shepherd's Neuk and Toddy Bridge, and the area wrought was very small. At that point the depth to the ironstone is 52 fms., and the dip of the strata is 1 in 4 in a south-easterly direction. As the field to the dip is practically untouched, we are not in a position to form a definite estimate of the reserves of ironstone it may contain, but there is clearly room for the extension of the position over several hundred acres, and it is not impossible that about 1,000,000 tons may be lying in the portion of the ground nearest to the old workings, on the assumption that the thickness of the seam remains within the limits quoted above.

Probably the principal difficulty likely to arise would be the depth, which can be expected to increase rather rapidly to the S.E.

Inzievar or Blairhall Blackband.—With the exception of a few thin and sporadic ironstones the next important horizon in ascending

* "The Geology of Central and Western Fife and Kinross," *Mem. Geol. Surv.*, 1900, p. 203.

sequence is the Inzievar or Blairhall Blackband, also known as Oakley Ironstone, Upper Comrie or No. 1 Comrie Ironstone. The two first designations are preferable, as there may be some confusion in the use of the two latter terms, which seem to have been also applied to the next lower ironstone, *i.e.* the "Success Blackband" [Lochgelly Ironstone] of the Comrie field.

From the fact that the Inzievar seam is the first seam of importance below the Index Limestone it is in a position comparable to that of the Balbardie seam of the Bathgate district (see p. 103), with which it has been taken to correspond.

The Inzievar Ironstone lies from 10 to 20 fms. below the Index Limestone, the average distance being usually about 15 fms., and it is from 5 to 10 fms. above the highest workable coal of the Limestone Coal Group of the district, namely, the Blairhall Main. From an economic standpoint the seam is well developed only in its type district of Oakley, Comrie, Blairhall and Grange (Fife, 33 S.W. 38 N.W., 32 S.E., 37 N.E.), though it can be recognised here and there as a thin position in the Central Fife coalfield.

The Oakley Ironstone field was the most important in Fife. The Inzievar seam alone was worked to a larger extent than the better-known Lochgelly Blackband, and what is left of it, added to the potentialities of the lower seams already referred to, make the district still the principal ironstone area of the county. The Inzievar Blackband was doubtless known early last century, but intensive mining began in the seventies, when the Carron Company, the Shotts Iron Company and Messrs. Merry & Cuninghaime sank pits on the grounds of Blairhall, Inzievar and Comrie. In 1883 the mining of the ironstone passed into the hands of the Coltness Iron Company, who worked it until 1907, and for most of the details obtained we are indebted to Messrs. Russell of that Company.

The wrought-out area is compact, and is divided into two nearly equal portions separated by the Comrie Burn, and the Comrie volcanic neck. The southern area extends from the crop near Oakley westwards beyond Bridgetown, south of which place it reaches Pitsoulie. It covers about 200 acres.

The outcrop of the northern wrought-out area is more westerly, owing to the fault which traverses the field. This area extends from Topitlaw westwards to north of Overton, and its northern limit lies some 200 yds. north of Shepherdlands. It covers about 400 acres. The total worked-out area of the Oakley Ironstone field is thus about 600 acres. To this must be added an area, not ascertained, which was worked by a deep pit half a mile due north of Overton Cottage, north-east of Muirside, on the extreme western edge of Fife, 33 S.W. The field was worked from a number of pit shafts, the more westerly ones being of considerable depth, as there is a steady north-west dip of about 10°.

At Blairhall the Inzievar seam had the following section:—

	Ft.	In.
Sandstone roof		
PARROT COAL	0	4
IRONSTONE (BLACKBAND)	1	3
Blaes	0	3
IRONSTONE (BLACKBAND)	0	1
Parrot Blaes	0	3

In the Over-Inzievar workings the thickness was 14 in., the same as in Messrs. Merry & Cuninghame's No. 4 South Comrie Mine, and according to the Forth Iron Company's general section it reached 20 in.

At the northern end of the field the following section obtained, according to an old report of D. Landale, who states that it thinned out to the north:—

	In.
Shale roof	
BLACKBAND	$\frac{3}{4}$
PARROT COAL, irregular	$2\frac{1}{2}$
BLACKBAND BALLS	$2\frac{1}{2}$
Coaly matter	$1\frac{1}{4}$
GOOD BLACKBAND	8
WILD PARROT	1
CHERRY COAL	5

An analysis of the Inzievar Ironstone, communicated by the Coltness Company, gave the following results:—

	Per cent.
Iron	34·24
Manganese	0·455
Silica	1·36
Lime	2·228
Magnesia	2·69
Phosphorus	0·327
Sulphur	0·352
Nitrogen	0·471
Coaly organic matter	13·465
Moisture, loss at 212°	2·78
Further loss at low red heat	39·52
Carbonic acid	31·50
Iron in calcined state dry	59·30

The above remarks all apply to the best parts of the wrought-out field. When the Coltness Company discontinued working the iron-stone, the western working face, from west of Bridgetown to Pitsoulie ran through much faulted ground, and the seam was only 9 in. thick. Similarly the old plans of the northern wrought-out area show evidence of thinning out along its north-western and northern margins.

Borings to the south of the Blairhall workings, that is, in the Valleyfield area, and borings to the north of the old Comrie workings, at and near Sunnyside, show a marked attenuation of the seam. This corresponds with the indications furnished by the working faces, and shows that there is little hope of any extension of a workable field along the direction of the strike.

On the other hand, there are reasons to believe that a fairly large area lies to the dip of the central portion of the old field. That central portion practically coincides with the volcanic neck of Comrie, so that the more immediately available reserves would lie to the west of it, in the Mains of Grange area, that is, between Overton Cottage to the north, and Grange Burn to the south. There would also be further possibilities to the dip, towards West Grange, at a depth approaching 200 fms. Taking the area nearest to the old Comrie workings to be between 150 and 200 acres, and assuming an average yield of 3000 tons per acre, it would probably contain

some half a million tons of ore. The deeper area, towards West Grange, is more difficult to estimate, as very few borings have reached the position, but there is ample room for reserves amounting to a million and a quarter tons and more.

In the above remarks no account has been taken of a small patch that appears to have been left unworked immediately east of the Comrie volcanic neck. As it lies at comparatively shallow depth it is legitimate to infer that its neglect may have been due either to thinning out or to impoverishment of the seam. Likewise the area lying between the south-eastern margin of the old Inzievar workings and Langleas was worked in small detached patches, suggesting that those portions left in would not be likely to prove profitable reserves.

UPPER LIMESTONE GROUP.

The general characters of the Upper Limestone Group in Fife are as in the Central Valley. Ironstones, as well as coals, are as a rule thinner and less numerous than in the underlying Limestone Coal Group, and there has been but little mining activity in these seams.

So far as could be ascertained, only one ironstone has been worked in the Upper Limestone Group of Central Fife. This ironstone occurs locally associated with a parrot coal, the *Lochore or Contle Parrot*, Contle being an old name for Glencraig where some of the old workings were situated (Fife, 26 S.E. and 34 N.E.).

On an average, the Lochore Parrot lies about 25 fms. above the position of the Index Limestone. It is typically developed in the district of that name, and has been traced from Ballingray southwards to Clune, and then eastwards in the direction of Pitcairn (Fife, 27 S.W.). The area between Ballingray and Clune was worked as a gas coal, while the area to the south of Glencraig (Contle) was apparently worked mainly for ironstone. There the seam was wrought from pits by the Forth Iron Company about and during the year 1852. Plans kindly communicated by Mr. Telfer of the Wilsons & Clyde Coal Co. show that the wrought-out area was quite small, covering only a few acres. Two of the pits, situated south of Glencraig House and close to it, reached the seam at depths of 12 and 6 fms. respectively, that is, near the outerop, which on the published geological map (1-in. sheet 40; 6-in. Fife, 31 S.W., Old Series) might be mistaken for the continuation of that of the Lochgelly Blackband seam.

Details regarding the exact nature of the seam could not be obtained, but the following sections, taken from boring records of the year 1846, show the subdivisions of the seam at the southern edge of the field, close to the River Ore, opposite the mouth of the old Lochgelly day-level. One of the records gives:—

			Ft.	In.
COAL, soft.	.	.	0	11
PARROT COAL	:	:	0	7
IRONSTONE, brown	.	.	0	3
Dark parting	:	:	0	1
IRONSTONE, dark brown	:	:	0	5
Blaes, dark	,	,	4	7

The other record shows—

		Ft.	In.
COAL, rough	.	1	1
COAL, parrot	.	0	8½
IRONSTONE, light brown	.	0	3½
Do. black	.	0	2
Do. dark brown	.	0	5½
Blaes	.	2	8

What may be the same seam was also worked from two small pits at Easterton, near Kelty (Fife, 34 N.E.). Plans or other documents were not available, but Mr. H. Rowan states that one of the pits was 10½ fms. deep, and worked a blackband which was from 15 to 20 in. thick. These pits, and another one farther north, were working during the fifties, and it is believed that the area wrought was small. The pit farthest north was situated close to the site of the present Aitken Pit, the shaft section of which records a 3-in. ironstone rib at a depth of 4 fms.: it is highly probable that it is the position of the seam worked by the adjacent old ironstone pit. The published edition of the Six-inch Geological Survey Map, Fife 30 S.E. (Old Series), tentatively refers the ironstone worked by the pits at Easterton, and near the Aitken Pit, to the Lochgelly Blackband; but there is now no doubt that the position is either that of the Lochore Parrot or near it.

A manuscript note on the original field map mentions old coal workings 300 yds. due north of Chapel Farm, Loch Ore, with a blackband ironstone lying 14 ft. below a gas coal, but nothing could be ascertained about these.

The reserves of ironstone connected with the Lochore Parrot cannot be estimated on the basis of present information. It is clear, that the ironstone varies very much, and it is doubtful whether under modern conditions the seam could be worked exclusively as an ironstone. On the other hand, the demand for cannel coal might eventually lead to the reopening of the seam, in which case the ironstone would be a useful by-product. The position extends over a large area, since it practically underlies the Upper Limestones north of the Lochgelly field, but the seam appears to have been looked upon as a workable subject mainly between Lochore and Glencraig. This means roughly about 600 acres, of which the iron-bearing portion would seem to be more developed at and near the southern edge.

In the extreme West of Fife, that is in the Blairhall district, a cannel coal worked long ago under the name of *Cadell's Parrot*, is in a stratigraphical position which corresponds with that of the Lochore Parrot. At Blairhall its waste lies 27 fms. above the top leaf of the Index Limestone. It is not recorded as having contained ironstone, but 3 fms. below it the Blairhall bore section shows:—

				In.
IRONSTONE	.	.	.	1
Black blaes	.	.	.	3
IRONSTONE	.	.	.	6½
Fakes	.	.	.	2½
Coaly blaes	.	.	.	5
COAL	.	.	.	9

The only other record of ironstone workings in strata, presumably of Upper Limestone age, is from the East of Fife, and is derived from a statement of D. Landale in his description of the Carhaulie field, which lies some 2 miles north-east of Kilmux (Fife, 21 N.W.). He speaks of "a great many bands of ironstone which were once worked and shipped to Largo." There are, unfortunately, no known records or plans of these workings, which must be very old, since Landale wrote in 1837.*

The exposed strata of the Carhaulie field are considered to belong to the Upper Limestone group, and as the pit shafts of the period alluded to could hardly have been deep enough to reach the lower coals it is probable that these ironstones belong to the Upper Limestone Group.

Little need be said of other ironstones recorded from the Upper Limestones, as none appears likely to possess economic value. Opportunity may be taken here to qualify a statement which appears on pp. 138-139 of the Geological Survey Memoir on Western and Central Fife. It mentions an ironstone—the Capledrae Ironstone—said to occur 20 ft. below the Capledrae Parrot, and to be of a thickness of 17 in. The source of that statement is not known now, and the mining records consulted show no ironstone at the position stated, with a single exception of an inconspicuous thin rib. The strata of the Capledrae district are steep and highly faulted, and it is conceivable that, owing to some confusion, the Lochore Parrot may have been taken for a position close below the Capledrae Parrot.

Passing reference can be made to isolated records of ironstones from the upper portion of the Upper Limestone Group, between the Castlecary Limestone and the Calmy Limestone. The thickest was cut by the Balfour Mains boring (Fife, 28 N.W.) at a depth of 184 fms. It consisted of 1 ft. 9 in. of blackband resting on 2 in. of stony coal. Another blackband, 9 in. thick, was met 10 fms. lower down. Apparently the stone, in both cases, did not seem of good quality, as it was not thought worth while to have it analysed. These ironstones are along the line of strike of strata exposed in the Kennoway Den, 2 miles N.E. of Balfour Mains (Fife, 20 S.E.), where thin ironstones occur. One of them was dug and used for "reddle" or "keel" (Geol. Surv. Memoir, p. 135), but it is not clear whether it is still exposed. A seam which may, or may not, be it, was analysed by Mr. T. Robertson, who measured the following section:—

	In.
CLAYBAND IRONSTONE	3
IRONY FAKE	6
COAL	5
IRONSTONE	3

The upper band is very poor, containing only 15·69 per cent. of iron, and a high percentage of silica and alumina. The lower one contains 30·27 per cent. of iron, with 7·87 per cent. of silica, and 20·30 per cent. of alumina.

From a stratigraphical standpoint it is interesting to note that

* "Report on the Geology of the East of Fife Coalfield, with Map and Sections," *Trans. Highland and Agric. Soc.*, vol. ix., 1837, p. 313.

two blackbands, 6 in. and 9 in. thick respectively, were met at almost the same position in a boring in the West of Fife, in the Grange district, west of Oakley.

SUMMARY OF CONCLUSIONS.

Lower Carboniferous Ironstones.

Of the sixteen ironstones reviewed in the preceding pages, seven only were worked as ironstones proper, independently of the concurrent raising of coal. The others are either the roofs of coal seams, or intercalated bands in the coals. These cannot be regarded as reserves that could be drawn upon in an emergency, since their extraction cannot proceed any faster than that of the associated coal, and they are, moreover, almost negligible owing to their thin development. They are merely by-products of the coal raising.

Of the true ironstone seams, the Pittencriff and the Kelty seams are too thin and irregular to contribute any noticeable reserves, while the thick Steelend ironstone cannot be expected to extend over a large area.

The seams which could be reopened with the best chances of success are the Denhead Ironstone, the Lower Comrie Ironstone, and the Inzievar Ironstone, the latter two providing the largest reserves left in Fife. There is the possibility of a small, practically untouched, field at Kilmux. The future of the Lochgelly Ironstone, and that of the ironstone associated with the Lochore Parrot, will be largely influenced by the demand for bituminous shale and cannel coal.

On the whole, the reserves of ironstone in Fife are extremely small when compared with the main iron-producing districts of the country, and are unsuitable for intensive development in times of crisis. The seams are generally so thin that labour—unless plentiful—could not be diverted to them profitably.

COAL MEASURES.

The Coal Measures of Fife cover a triangular area stretching along the coast from Dysart to Leven and extending inland to Markinch. Their boundary on the west is defined by outcrop; to the north they are faulted against Carboniferous Limestone strata, while seawards they dip below the Upper Barren Red Measures and extend an unknown distance beneath the Firth of Forth. A north-and-south anticlinal axis runs across the area 1 to $1\frac{1}{2}$ miles approximately from its western boundary, and before this is reached from the east all the higher seams have cropped out. The trough lying west of this axis contains only the lower seams, and is much broken up by parallel east-and-west faults, all of which have a downthrow to the south. In addition to this area there is a small outlier of Coal Measure rocks at Kinglassie, a few miles to the west. They occupy here a basin limited by outcrop on every side except the north, where a large east-and-west fault brings them against the Carboniferous Limestone Series.

Lower Dysart Ironstone.—The only ironstone of any importance in the Coal Measures of the Dysart, Wemyss and Leven area is a clay-

band which overlies the lowest workable coal, the Lower Dysart seam. The ironstone is developed chiefly in the western part of the coalfield and dies out eastwards. At Wellsgreen, for example (6-in. Map, Fife, 28 S.E.), there is no trace of the ironstone in a bore passing through the Lower Dysart Coal. It comes in, however, at Tillybreck, about $1\frac{1}{2}$ miles to the west (Fife, 28 S.W.), where it was proved in No. 3 bore. About a mile south of this locality, at Lochhead Pit, and again in the Francis Pit at Dysart, clayband is found above the Lower Dysart Coal. The sections are as follows:—

<i>No. 3 bore Tillybreck (at 46 fms.).</i>		<i>Lochhead Pit.</i>	<i>Francis Pit, Dysart.</i>
	Ft. In.	Ft. In.	Ft. In.
Blaes	3 0	Blaes	0 10
CLAYBAND	0 11	No. 5 CLAYBAND, with stone	1 0
Blaes	1 6	Blaes	0 8
Fakes	1 0	No. 4 CLAYBAND	0 3
Blaes	1 9	Blaes	0 9
COAL	1 2	No. 3 CLAYBAND	0 3
Fireclay	0 6	Blaes	0 8
Blaes	1 2	Fakes	0 1
COAL	1 2	No. 2 CLAYBAND	0 1
		Fakes	0 2
		No. 1 CLAYBAND	0 10
		Fakes	0 4
		COAL	1 1
		Stone	0 2
		COAL	2 3

To the north-west of Dysart, and near the outcrop of the seam, a section measured by David Kerr in the Sweet Dub Pit, Gallatown (Fife, 36 N.W.), showed several claybands above the Lower Dysart Coal. Due west of Lochhead there is no evidence available either on the crest of the anticline referred to above or in the trough to the west of it until we reach the outcrop of the seam about a mile south of Thornton (Fife, 28 S.W.). Here the Fife Coal Co. are working the Lower Dysart Coal by an incline from the surface. A 4-in. blackband ironstone is here associated with the coal, representing apparently the band of parrot found in other districts. The Balgonie Coal Company found several feet of blaes with ironstone ribs in the roof of the same seam in the Julian Pit about half a mile north of Thornton Station. There is no exposure visible now however, and very little can be said of the horizon. The sections in the Sweet Dub and Julian Pits are:—

<i>Sweet Dub Pit, Gallatown.</i>		<i>Julian Pit, Thornton.</i>	
	Ft. In.	Ft. In.	
Blaes		Blaes and IRONSTONE ribs	
IRONSTONE	0 3	IRONSTONE	1 1
Blaes	1 3	Blaes and balls	2 2
IRONSTONE	1 3	LOWER DYSART COAL	
Blaes	2 9		
IRONSTONE, darker	0 3		
Blaes	0 3		
IRONSTONE	0 10		
Blaes	0 3		
Hard grey stone	0 9		
COAL	1 3		
Stone	0 1		
COAL	2 4		

A short distance north of the Julian Pit the basin of Coal Measures narrows down to about half a mile in width, broadening out again to the north of the River Leven. Neither in the narrow part nor beyond it has the ironstone been obtained in good thickness. Where the coal is worked the overlying blaes contains ironstone ribs, but if possible both are kept up. At Quarry Park, to the north of Balgonie (Fife, 28 N.W.), in No. 5 bore, a 6-in. clayband is recorded 12 ft. above the Lower Dysart Coal, but another bore in the vicinity notes only blaes and balls. Half a mile north of Milton of Balgonie, again, the coal was reached at a depth of $57\frac{1}{2}$ fms., but had only a 3-in. clayband about one foot above it. The evidence suggests that there is nothing to be got to the north of Balgonie, but the geological structure in that district is not satisfactorily known, and no definite conclusion can be drawn. This ironstone was worked in the early days of the Scottish iron industry. Mushet* includes the "Dysart Balls" as one of the ironstones used at Carron in 1768. Early in the nineteenth century the Carron Company mined ironstone on the outcrop of the Lower Dysart Clayband immediately to the south of Coaltown of Balgonie. The area over which the seam was worked here is about $7\frac{1}{2}$ acres. Probably the same company won ironstone at other parts along the outcrop, and the old Balgonie furnace on the north side of Quarry Park Plantation suggests that the ore was smelted there. The area worked at Tillybreck is more definitely known from an old plan by David Kerr showing the position of the face in 1839. It would appear that they had worked the ironstone right to the Buckhaven fault, which runs east-and-west, and is proved in the Muiredge, Rosie and Wellsgreen workings. North of the Rosie Pit it has a throw of 60 to 70 fms. down to the south, but seems to die out before reaching Earlseat. The seam dipped gently to the south. To the west also the workings were cut off by a small N.W.-S.E. fault known in the present Earlseat Colliery. Besides the day level two shafts served the ironstone workings, one near the outcrop on the north, and the other just south of Earlseat farm. The thickness of the seam was 20 to 24 in. It was also worked later about the year 1860. The quality of the Lower Dysart Ironstone is shown in several analyses kindly given by the Wemyss Coal Co. Ltd. The ribs referred to in No. 1 are shown in the section at Lochhead Pit given above.

* See p. 7.

	1.		2.	
	Sample as Received.	Calcined Sample.	Sample as Received.	Calcined Sample.
	Per cent.	Per cent.	Per cent.	Per cent.
Peroxide of iron . . .	1·72	44·17	·40	39·23
Protoxide of iron . . .	28·18	...	27·57	...
Bisulphide of iron . . .	·38	...	1·59	...
Oxide of manganese . . .	·80	1·04	1·30	1·58
Alumina	9·77	12·69	9·82	12·01
Silica	21·04	27·33	30·25	37·04
Lime	2·65	3·50	3·46	4·23
Magnesia	5·74	7·53	2·41	2·94
Sulphuric acid	·17	·45	trace	1·28
Phosphoric acid	1·08	1·41	1·27	1·54
Carbonic acid	22·50	...	21·80	...
Titanic acid	1·42	1·86	·13	·15
Arsenic acid	·02	·02	trace	trace
Coaly matter	4·53	...	...	...
	100·00	100·00	100·00	100·00
Iron	23·29	30·91	22·46	27·46
Manganese	·55	·71	·93	1·12
Sulphur	·27	·23	·85	·51
Phosphorus	·47	·61	·55	·67
Arsenic	·012	·015	...	...
Loss on calcination . . .	23·84	...	18·20	...

1. Average of 6 ribs of ironstone in Lochhead Colliery.

2. Earlseat Colliery. Thickness 12 in.

The prospects of the Lower Dysart Ironstone are somewhat doubtful. The coal below it is being worked at present by the Wemyss Coal Co. at Earlseat and Lochhead, by the Balgonie Colliery Co. at Balgonie and by the Fife Coal Co. at Thornton, and the idea of working the ironstone has been considered, but has not been adopted. Shortly before the war the price quoted for one sample of ironstone from this horizon by the Carron Company was 7s. per ton raw, or 12s. 6d. per ton calcined, delivered at Carron. The quality of this sample, however, was considered to be poor compared with what could be turned out if a good demand existed.

Ironstone in the position of the Sandwell Coal.—Bores in the Thornton and Balgonie district show the existence of an ironstone horizon about 20 fms. above the Dysart Main seam. In bores passing through this position north of Coaltown of Balgonie ironstone ribs from 1 to 3 in. thick are frequently recorded, associated with thin coals, but in some cases only the coals are found. They occupy approximately the same position as the Sandwell Coal of the Dysart area. As it is only in a few instances that coal of workable thickness is recorded at this horizon, there does not seem to be much chance of exploitation.

Chemiss Ironstone.—The Chemiss Coal is confined to the eastern portion of the coalfield. In the Leven district it contains no ironstone, but in the Michael Pit at East Wemyss a thin clayband is

sometimes found on the pavement of the workings, and in some places this has been extracted. The seam is in section as follows:—

	Ft. In.
Blaes roof	
CRAW COAL	2 0
Stone	0 5
CHERRY COAL	1 0
SPLINT COAL	2 6
CLEAN COAL	1 0
Parting	0 1
BINKS COAL	3 4
IRONSTONE	0 3
Blaes	0 6
COAL	0 6
Faky Sandstone	

An analysis of the Chemiss Ironstone from Michael Colliery, kindly furnished by the Wemyss Coal Co. Ltd., shows:—

	Sample as Received.	Calcinced Sample.
	Per cent.	Per cent.
Peroxide of iron	1·84	71·94
Protioxide of iron	39·24	..
Bisulphide of iron	·56	..
Oxide of manganese	1·20	1·88
Alumina	2·43	3·80
Silica	4·50	7·06
Lime	3·76	5·90
Magnesia	4·32	6·78
Sulphuric acid	·10	·62
Phosphoric acid	1·12	1·75
Carbonic acid	31·30	..
Titanic acid	·15	·23
Arsenic acid	·03	·04
Coaly matter	9·45	..
	<u>100·00</u>	<u>100·00</u>
Iron	32·08	50·36
Manganese	·86	1·35
Sulphur	·33	·25
Phosphorus	·49	·77
Arsenic	·02	·03
Loss on calcination	36·30	

Approximate thickness 4 inches.

Bogside Ironstone.—This is the only ironstone known in the Coal Measures of the Kinglassie area. The total thickness of these strata here is much smaller than in the Dysart and Leven area, and correlations between the two are untrustworthy. The Ironstone is only known on the west side of the basin, and even there it is not at all constant. It outcrops in semi-circular fashion from west of Kinninmonth Upper Pit, by way of North Bogside, to the north side of Bog Lochty. On the north it is cut off by the boundary fault. The ground was bored to a considerable extent about the middle of the nineteenth century, but the records now left are imperfect. The journals give conflicting evidence, but seem to agree that the Ironstone does not extend far to the east—not so far as Kinninmonth Lower Pit. The seam appears to have been first noticed in the year 1839, and is a blackband ironstone up to 2 ft. in thickness, overlying a coal 2 to $2\frac{1}{2}$ ft. thick. Near Kinninmonth the Ironstone was 21 in. when worked, and 13 in. of this was said to be

real blackband. Goodall's Pit, just east of the Kinninmonth Upper Pit, was taken over by the Lochgelly Iron and Coal Co. somewhere about 1850 to 1855, and was sunk to the Ironstone. It was worked for some time and carted to Lochgelly. A bore put down for the Lochgelly Company in 1856 (Steel's), about a quarter of a mile to the south, failed to find anything in the Ironstone position. Several bores put down in the same year round about the position of the Kinninmonth Upper Pit (as marked on the present maps) showed from 6 in. to 2 ft. 6 in. of ironstone. Reports on the progress of the work, made towards the end of 1857, show that it was of doubtful success, and the ironstone was said to be not of the first class. Three pits had been sunk to the seam, two to the south and one to the north of a 7-fm. fault, the position of which is not known. In the pits to the south the Ironstone was 18 in. thick. In the other it was worthless. Operations do not seem to have been carried on much later than the end of 1857.

At a later period—somewhere about 1870—the Ironstone was opened up on the outcrop, east of North Bogside Farm, and worked by means of an incline from the surface for about two years. This time it was carted to Oakley to be smelted. The seam was about 18 in. thick in the workings at that time. All traces of the outerop workings have now disappeared.

The Ironstone is nowhere exposed at present, nor has any definite record of its quality been found. As elsewhere the working of adjacent coals is the only circumstance which is likely to make this Ironstone of any use in the future. Should the Ironstone ever be worked, the maximum amount that is likely to be got would not be more than 500,000 tons, assuming a thickness of 1 ft. 8 in. and an area of about 96 acres.

ESTIMATED RESERVES IN FIFE.

Name of Seam.	For Description see	Area in Acres.	Reserves in Tons.		
			Proved.	Probable.	Possible.
(1) Coal Measures.					
Bogside Blackband	pp. 161-2	95	...	494,000	...
(2) Limestone Coal Group.					
Blairhall or Upper Comrie Blackband	pp. 151-5	150	...	468,000	...
Blairhall or Upper Comrie Blackband	pp. do.	400	...	...	1,248,000
Lower Comrie Blackband	pp. 146-7	800	...	...	1,872,000
Lochgelly Blackband	pp. 148-51	620	...	...	2,402,400
Blackband at Kilmux	p. 152	200	...	...	884,000
Blackband in roof of Lochgelly Splint Coal at Glencraig	pp. 143-4	120	249,600	...	...
Blackband in roof of Mynheer Coal at Lochgelly	pp. 142-3	47	80,000	...	...
Clayband in roof of Five-foot Coal at Lethans	pp. 140-1	129	77,400	...	...
(3) Lower Limestone Group.					
Denhead Blackband	pp. 138-9	150	...	...	468,000
 Totals . . . .		...	407,000	962,000	6,874,400

CHAPTER V.

BEDDED ORES OF CARBONIFEROUS AGE (*continued*).

MIDLOTHIAN AND HADDINGTON.

INTRODUCTION.

THE Midlothian and Haddingtonshire Coalfield (see Fig. 13) consists of an area of Carboniferous Rocks stretching along the south shore of the Firth of Forth from Portobello to Port Seton, a distance of about 8 miles, and extending inland for a distance varying from nearly 20 miles on the west side to about 9 on the east. Structurally it may be described as consisting of two parallel troughs with axes running about N. 30° E. to S. 30° W., and pitching at a very low angle towards the N.E. The anticlinal axis separating these troughs runs from Gorebridge at the south end to the sea at Prestonpans. Towards the south the anticline gradually becomes flatter and all the coal-bearing strata crop out. To the north also, the anticline gradually flattens out.

On the west side of the Midlothian basin the Calciferous Sandstone Measures outcrop from below the Carboniferous Limestone Series, and are cut off by a fault bringing them against the Old Red Sandstone rocks of the Pentland Hills. In the central portion of the basin there is a large tract of Coal Measures, underneath which the Limestone Coal Group extends, but at a depth in the northern portion of the field of over 400 fms. On the eastern side of the trough the Limestone Coals crop out, leaving a core of Lower Limestone Measures along the crest of the anticline except at the ends, where some of the coals connect up with the Haddingtonshire basin, due to the flattening out of the folding.

The Haddingtonshire basin is smaller and flatter than the Midlothian one, and, except for a very small area on the coast, the Coal Measures and Millstone Grit are absent. The Limestone Coal strata undulate gently and form several irregular minor basins containing workable coals. To the east they gradually crop out. The total thickness of strata, and the number of workable seams are greatest on the north-west side of the Midlothian Basin. Towards the south and east there is a gradual thinning of the measures, as can be seen from the accompanying sheet of vertical sections (Fig. 14).

In both basins there is a large undersea field to the north. Some of the chief features of the district from the mining part of view are—the extremely high inclination of the seams where they outcrop on the west; the great depth of the Limestone Coal Group in the centre of the Midlothian Basin; the absence of igneous

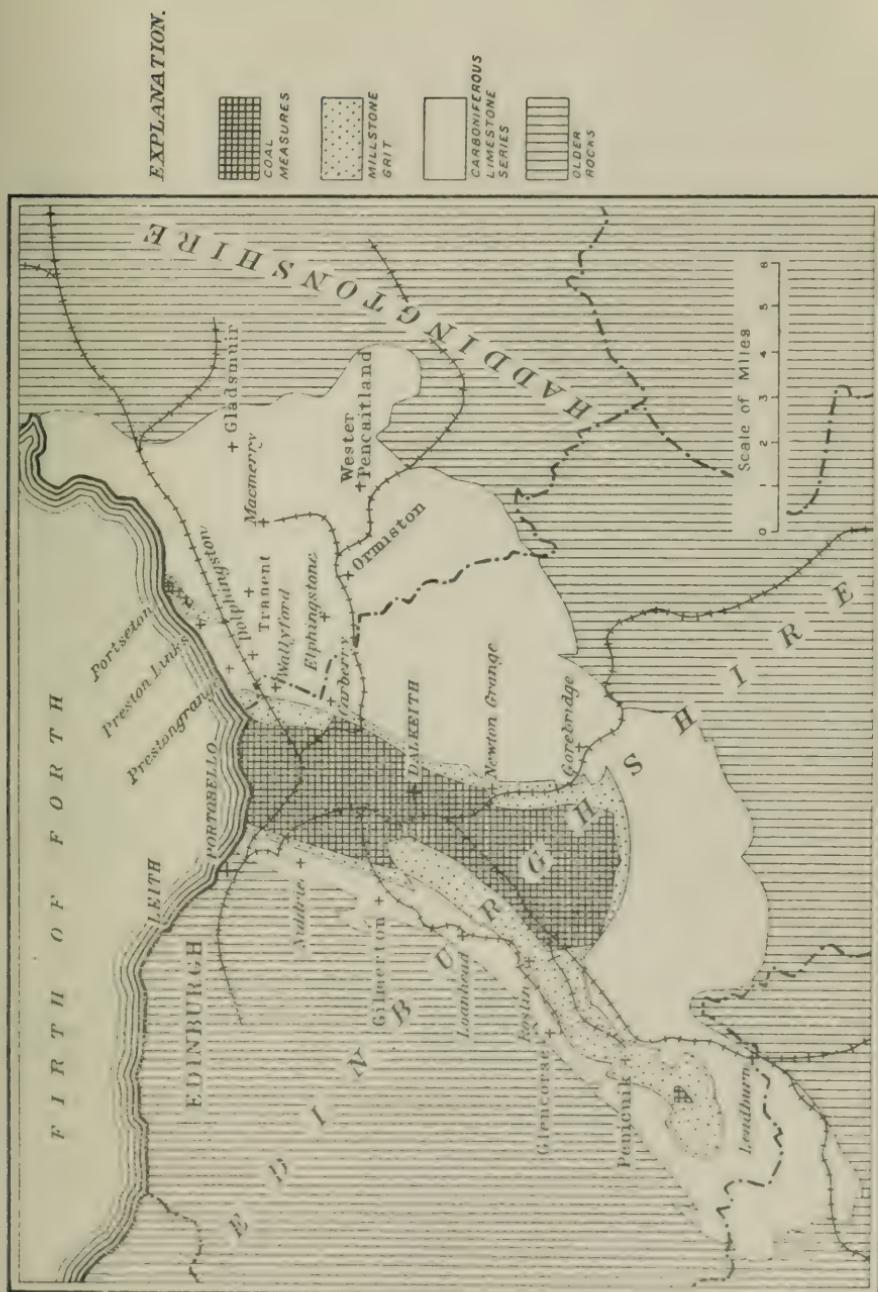


FIG. 13.—Geological Sketch-Map of Midlothian and Haddington Coalfield.

intrusions except in a very small area near Prestonpans; and the very general absence of fire damp.

The fact that the Midlothian Coalfield has, up to the present, been very little exploited, makes it impossible to give any definite figure for the ironstone resources. The Limestone Coal Group in the centre of the basin is so little known that data built upon the areas worked at present on both sides cannot be carried forward with any pretence of reliability. Outside of the small areas definitely proved in working, therefore, we can only hope, by tracing the ironstone horizons from place to place, to indicate the positions in which ironstone should be more particularly looked for in subsequent development. These ironstone horizons are frequently of notable persistence, though varying rapidly from place to place, and may quite unaccountably swell to workable proportions at any point.

In recent years the non-existence of blast furnaces in the vicinity has to a large extent discouraged ironstone mining in the district. Ribs a few inches thick associated with some of the coal seams could be profitably extracted if dealt with locally, though the cost of transport to the furnaces in the Central Coalfield area leads to their being left in the waste at present.

The positions of the iron-bearing horizons in the area under description are shown in the accompanying vertical section sheet (Fig. 14), and it will be noticed that, with one exception, those which are of workable thickness, or which could be worked in conjunction with associated coals, are confined to the Limestone Coal Group (The "Edge Coal Group" of Midlothian).

It will also be seen that it is possible to trace the most important of these horizons from one district to another with a fair amount of certainty. Below the Carboniferous Limestone Series no ironstone of the least importance is known.

For a full account of the geology of the Midlothian and the Haddington basins reference may be made to the following Memoirs of the Geological Survey: "Geology of the Neighbourhood of Edinburgh," 1910, and "Geology of East Lothian," 1910.

LIST OF ABBREVIATIONS USED IN FIG. 14.

A.	.	.	.	.	.	Andrews Coal
A.P.	.	.	.	.	.	Arniston Parrot Coal.
B.	.	.	.	.	.	Blackchapel Coal.
B.D.	.	.	.	.	.	Blackbird Coal.
BG.	.	.	.	.	.	Beggar Coal.
BL.	.	.	.	.	.	Blue Coal.
BR.	.	.	.	.	.	Browns Coal.
BR. SP.	.	.	.	.	.	Bryans Splint Coal.
C.	.	.	.	.	.	Coal.
2 Ft. C.	.	.	.	.	.	Two-foot Cherry Coal.
3 Ft.	.	.	.	.	.	Three-foot Coal.
4 Ft.	.	.	.	.	.	Four-foot Coal.
5 Ft.	.	.	.	.	.	Five-foot Coal.
C.J.	.	.	.	.	.	Corbie Jewel Coal.
CL.	.	.	.	.	.	Carleton Coal.
COR.	.	.	.	.	.	Coronation Coal.
C. SP.	.	.	.	.	.	Corbie Splint Coal.
C. SP. & CR.	.	.	.	.	.	Corbie Splint and Craig Coals.
D.	.	.	.	.	.	Diamond Coal.
No. 1 D.	.	.	.	.	.	No. 1 Diamond Coal.
No. 2 D.	.	.	.	.	.	No. 2 Diamond Coal.
F.	.	.	.	.	.	Flex Coal.

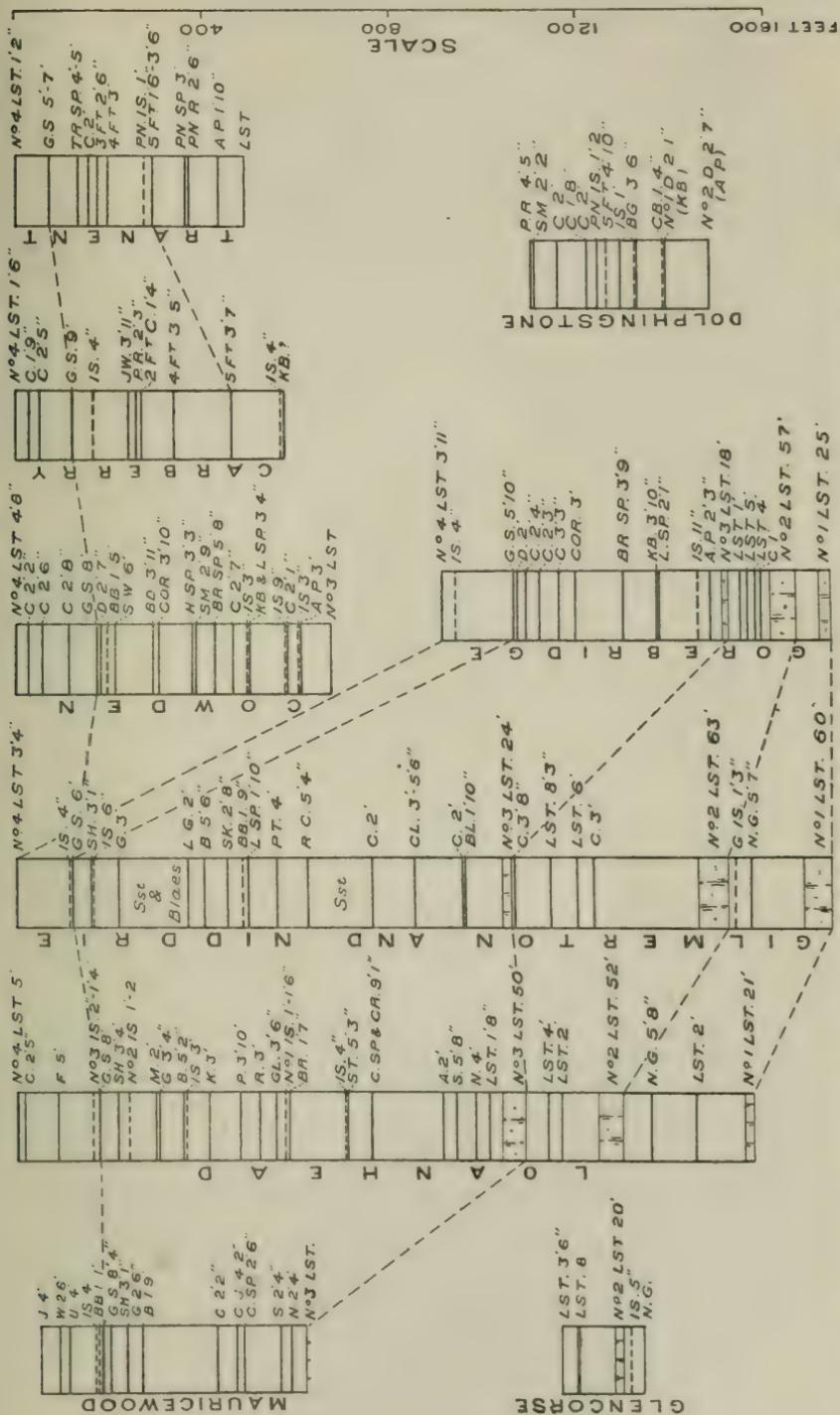


FIG. 14.—Comparative Vertical Sections of the Limestone Coal and Lower Limestone Groups in the Midlothian and Haddington Coalfield.

G.	.	.	.	Gillespie Coal.
GL.	.	.	.	Glass Coal.
G.S.	.	.	.	Great Seam Coal.
H. SP.	.	.	.	Hard Splint Coal.
IS.	.	.	.	Ironstone.
No. 1 IS.	.	.	.	Loanhead No. 1 Ironstone.
No. 2 IS.	.	.	.	Loanhead No. 2 Ironstone.
No. 3 IS.	.	.	.	Loanhead No. 3 or Rumbles Ironstone.
BB. I.	.	.	.	Blackband Ironstone.
CB. L.	.	.	.	Clayband Ironstone.
G. IS.	.	.	.	Gilmerton Blackband Ironstone.
PN. IS.	.	.	.	Penston Ironstone.
J.	.	.	.	Johnstone Coal.
JW.	.	.	.	Jewel Coal.
K.	.	.	.	Kittlepurse Coal.
KB.	.	.	.	Kailblades Coal.
L.G.	.	.	.	Little Gillespie Coal.
L. SP.	.	.	.	Little Splint Coal.
LST.	.	.	.	Limestone.
No. 1 LST.	.	.	.	Gilmerton Limestone.
No. 2 LST.	.	.	.	North Greens Limestone.
No. 3 LST.	.	.	.	Bilston Burn Limestone.
No. 4 LST.	.	.	.	Index Limestone.
M.	.	.	.	Moffats Coal.
N.	.	.	.	North Coal.
N. G.	.	.	.	North Greens Coal.
P.	.	.	.	Peacock (or Stinkie) Coal.
PN. R.	.	.	.	Penston Rough Coal.
PN. SP.	.	.	.	Penston Splint Coal.
P.R.	.	.	.	Parrot Rough Coal.
PT.	.	.	.	Peacocktail Coal.
R.	.	.	.	Rough Coal.
R.C.	.	.	.	Real Corbie Coal.
S.	.	.	.	South Coal.
SH.	.	.	.	Stairhead Coal.
SK.	.	.	.	Stinkie Coal.
SM.	.	.	.	Smithy Coal.
SST.	.	.	.	Sandstone.
ST.	.	.	.	Stoney Coal.
S.W.	.	.	.	Siller Willie Coal.
TR. SP.	.	.	.	Tranent Splint Coal.
U.	.	.	.	Union Coal.
W..	.	.	.	Waverley Coal.

CALCIFEROUS SANDSTONE SERIES.

Two horizons may be mentioned where small supplies of ore were obtained for the Carron Ironworks in the early days of its career. On the shore at Granton Harbour the Wardie shales are well exposed in a syncline trending N. and S., and low down in the sequence occurs a black shale, 70 ft. thick, containing abundant ironstone nodules. This bed is exposed on both the east and west sides of the harbour, and the clayband nodules were formerly collected and smelted at Carron (see "Geology of Neighbourhood of Edinburgh," *Mem. Geol. Surv.*, 1910, p. 77).

Immediately to the east of Gullane Point, at the north end of Aberlady Bay, the Carron Company worked a bed of ironstone nodules about the beginning of the nineteenth century. The bed is 6 to 8 ft. thick where exposed on the shore. It consists of fireclay blaes, and the clayband nodules are found chiefly in the lower 2 ft. An adit was driven into the bank about 30 ft. back from high water mark, but there is nothing to show to what extent the deposit was worked. Even in those early days, however, it would not pay to

follow a bed of nodules any distance underground. The workings have given the name Ironstone Cove to the locality (see "Geology of East Lothian," *Mem. Geol. Surv.*, 1910, p. 85).

LOWER LIMESTONE GROUP.

Gilmerton Ironstone.—This seam, as shown by the vertical section given in Fig. 14, is in the Lower Limestone Group, between the Gilmerton and the North Greens Limestones, 2 to 3 fms. below the latter, and $5\frac{1}{2}$ fms. above the North Greens Coal.*

The comparative sections given below show how the seam varies when followed from north to south. About 2 miles north of Gilmerton, just south of the Brunstane Burn, a cross-cut driven in one of the Niddrie and Benhar Coal Company's pits through this horizon showed two coals separated by 10 in. of blaes, but no ironstone was found (Edinburgh, 4 S.W.). At Gilmerton itself (Edinburgh, 8 N.W.), the section of the seam as worked showed 15 in. of blackband ironstone, the various sections given differing somewhat in detail. A short distance south of the Gilmerton workings a mine was driven on the Ironstone position by the Glasgow Iron Co., from the outcrop to a depth of between 15 and 20 fms. Ironstone was got, but the thickness and quality are not recorded. To the south, however, it dies out, for where exposed at Loanhead the section gave 2 in. ironstone, 6 in. wild parrot coal, and 6 in. parrot coal, whilst in the Bilston Burn, about a mile further on, a parrot and rough coal, 2 ft. 4 in. thick, is found in the Gilmerton Ironstone position, and was worked to a small extent in 1864 (Edinburgh, 7 S.E.). Two miles further to the south, however, an ironstone band 5 in. thick is exposed in the same position in Glencorse Burn.

The Gilmerton field is bounded north and south by the Drum and Sheriffhall faults respectively, both being dip faults running east-and-west. Another dip fault, the "Great Dyke," with a large vertical displacement and with a downthrow to the north, divides the field into two portions. There are also numerous subsidiary dislocations. The strata dip a little to the south of east at an angle of about 30° at the outcrop of the Ironstone, but the dip becomes steeper in depth and the flattening out into the bottom of the basin takes place at a depth of between 500 and 600 fms. In addition to ironstone, coal has been worked to some extent in the field (Edinburgh, 8 N.W.).

In 1872 the ironstone seams were leased by the Glasgow Iron and Steel Co., from Sir David Baird of Newbyth, and the Venturefair Pit † was reopened in 1878 and worked for ironstone until 1885.

The workings were in two portions, separated by the "Great Dyke" described above. The southern portion was worked from the Venturefair Pit, and from the No. 5 Pit, further south, near the Edinburgh-Lasswade Road. The total depth of the Venturefair shaft was 96 fms., and pumping was done from that depth with 15-in. bucket pumps in two lifts. The amount varied from 300 to 500 gallons per minute, a good deal being surface water. Winding was done from a depth of 80 fms., at which level a cross-cut driven N.W. from the shaft tapped the ironstone. The bottom of the shaft was between

* For section of this coal see p. 191.

† Sunk for coal in 1829 to a depth of 96 fms.

the North and Vexhim Coals. An incline was driven down on the Ironstone to a distance of 100 fms. from the pit bottom level, but only the first 30 or 40 fms. of this was worked.

From this depth to the surface the seam is exhausted between the Venturefair Pit and the Edinburgh-Lasswade Road.

The No. 5 Pit, about 200 yds. north of the Edinburgh-Lasswade Road, was sunk to the North Greens Coal, and a cross-cut driven east to the Ironstone. Thence the workings extended to the south through a fault and, crossing the road, stopped just north of West Edge farmhouse.

The downthrow portion of the field was worked from the No. 3 Mine, on the west side of the village. Here the seam was all worked out from the crop to a depth of between 80 and 100 fms., from the Great Dyke to the extent of the leasehold to the north. In both portions of the field, except to the south of No. 5 Pit, where all the working was longwall, the portion of the seam above 100 fms. was worked stoop and room, and that at a greater depth longwall.

Both in depth and to the north the Ironstone is reported to have maintained its quality and thickness unchanged, so that very probably it will remain workable in this direction as far as the Drum fault. Towards the south evidence is lacking, and the field is so much cut up by faults that working would be very troublesome. It is only about half a mile to the Edgefield fault where the Ironstone has died out.

In depth there is no evidence regarding its behaviour, but it must be nearly 600 fms. deep in the position of the Gilmerton Melville bore.* We may take it as of workable thickness to a depth of over 200 fms. at least.

The height of the working was between 3 ft. and 3 ft. 6 in. Mr. M'Gowan, formerly manager at Gilmerton, stated that the parrot coal in the Ironstone working did not sell well. The North Greens Coal seam was worked at the same time as the Ironstone, but not nearly to the same extent.

No ore reserves can be put down as proved in regard to this iron-stone, but, upon the evidence given above, we may take as probable reserves the area between the Drum fault and the old workings at Gilmerton to a depth of 100 fms., and everything below the Gilmerton workings to a depth of 200 fms. This, at an average inclination of 40°, would give about 475,000 tons in an area of 116½ acres.

The ore at a greater depth than this can only be considered as possible, and, taking a workable limit as 400 fms., about 900,000 tons of such ore would exist below the Gilmerton workings, under a surface acreage of 225, assuming the dip to remain unchanged. This estimate does not include the area under the village.

Sections of Gilmerton Ironstone:—

Niddrie. (Brunstane Cross-cut).				Gilmerton.			
		Ft.	In.			Ft.	In.
Blaes	.	14	9	Blaes	.	8	0
COAL	.	1	0	BLACKBAND	.	1	3
Blaes	.	0	10	Fireclay	.	0	6
COAL	.	1	6	PARROT COAL	.	1	3
				FREE COAL.	.	0	8

* About a third of a mile S.E. of Gilmerton Station.

*Gilmerton (section furnished
by the Manager).*

	Ft.	In.		Ft.	In.
Blaes roof			Blaes .	. 7	6
BLACKBAND, black, poor	1	0	IRONSTONE .	. 0	5
BLACKBAND, brown	0	5	Blaes .	. 22	0
Fireclay .	. 9	4			
COARSE PARROT .	. 1	0			
ROUGH COAL .	. 0	6			
Freestone					

The following analysis of the Gilmerton Blackband Ironstone (dated 15th July 1885) has been kindly given by the Glasgow Iron & Steel Co. Ltd. :—

	Per cent.		Per cent.
SiO ₂ .	10·00	Fe .	51·45
Fe ₂ O ₃ .	70·71	S .	0·54
FeO .	1·61	P .	0·38
MnO .	2·10		
Al ₂ O ₃ .	6·97		
Sulphuric acid .	1·37		
Phosphoric acid .	0·87		

It is not likely that the Gilmerton field will ever again be worked for ironstone alone, so that the value of the reserves of blackband existing here will depend upon the condition of the associated coals. Accordingly some notes upon the thickness and character of the workable coals in this district are given in Appendix I. at the end of this chapter under the heading "Future of the Gilmerton Coalfield."

LIMESTONE COAL GROUP.

The lowest ironstone recorded in the Limestone Coal Group is a band 12 $\frac{3}{4}$ in. in thickness got below the No. 2 Diamond Coal in a cross-cut at Dolphington Colliery, to the N. of the Roman Camp Hill anticline (Hadd., 9 N.W.). The section is as follows :—

			Ft.	In.
COAL (No. 2 Diamond)	.	.	3	2
Sandstone .	.	.	6	6 $\frac{1}{2}$
Fakes and Blaes .	.	.	2	6
Blaes .	.	.	1	10
IRONSTONE .	.	.	1	0 $\frac{3}{4}$
Blaes				

This is the only record of ironstone in this position, and it was not thoroughly investigated. In the Newtongrange and Gorebridge district there is a very persistent 3-in. rib of clayband ironstone locally called the "bane," in the roof of the Arniston Parrot Seam.* Its removal, however, would spoil the roof of the coal workings, so that it cannot be profitably extracted.

At Prestonlinks, a 3-in. clayband ironstone was found on the same horizon—whilst a thin band is found above the Hauchielin Coal south of Ormiston, this also being in the Arniston Parrot position.

A few fathoms higher up in the series, an ironstone is recorded

* "Geology of Neighbourhood of Edinburgh," Mem. Geol. Surv., 1910, p. 220.

at several places on the eastern side of the Midlothian Basin. At Cowden Colliery, Dalkeith, the section is as follows:—

	Ft.	In.
Blaes	21	0
IRONSTONE	0	9
COAL	2	1
Sandstone	4	5
COAL	1	7
Sandstone and blaes	11	3
ARNISTON PARROT COAL	3	0

There is no further mention, however, either of this ironstone or of its associated coal.

The following section in a bore about $\frac{3}{4}$ mile N.W. of the Cowden Pit may refer to the same horizon:—

	Ft.	In.
Blaes		
IRONSTONE	0	6
Blaes	2	10
IRONSTONE	0	6
Blaes	0	9
IRONSTONE	0	3
Strata	13	9
COAL	0	8
Strata	6	1
COAL	2	4
Strata	18	0
LIMESTONE		

At the Emily Pit, Gorebridge, there is also on record an ironstone 11 in. thick, about 10 fms. above the Arniston Parrot, as shown below. It was passed through in the sinking of the shaft, but was not examined carefully, and is now hidden and inaccessible, and is not known elsewhere in the vicinity.

	Ft.	In.
COAL, ROUGH	0	9
COAL, PARROT	1	3
Blaes	1	7
IRONSTONE	0	11
Blaes	14	11
COAL	2	1
Blaes	1	6
COAL	1	3
IRONSTONE bands	2	9
Blaes	9	7
IRONSTONE	0	2
Blaes	0	6
PARROT SEAM	2	3

It is doubtful whether the ironstone shown in the last three examples cited is merely of local occurrence, or whether further investigation would show the existence of a workable seam. The point is worthy of attention when further prospecting is taken in hand.

Kailblades Coal.—This is a well-marked horizon on the east of the Midlothian Basin and in East Lothian. At Gorebridge and Newtongrange it is 70 to 80 ft. above the Arniston Parrot, but in neither of these areas is there an ironstone along with it. In the Cowden shaft, however, 2 miles further north, a 3-in. ironstone band

was found in the roof of the Kailblades seam. The coal is of good quality, and if it were worked in conjunction with the Little Splint Coal 2 ft. below it, the ironstone might be extracted. At Carberry, a little over a mile to the north of Cowden, a 4-in. ironstone was found during the sinking of the shaft, about 10 ft. above a coal which is supposed to be the Kailblades. The strata below it, however, have not been explored.

Going round the north end of the Roman Camp Hill anticline we find the same position in the old pit at Dolphington. The coal is here called the No. 1 Diamond, and 4 in. of clayband were found above 15 to 38 in. of splint coal.

At Prestonlinks also, two ironstone ribs above a 7-in. coal were found in the Kailblades position by a bore put down from the Great Seam workings.

From Cowden to Prestonlinks, however, the coal has not been worked, nor the position thoroughly investigated. The persistence of the ironstone rib, however, would justify notice being taken of this feature in future exploration.

In the centre of the East Lothian Coalfield the Nos. 1 and 2 Diamond Coals, corresponding to the Kailblades and Little Splint of Gorebridge and Cowden, are being worked to a considerable extent from north of Macmerry to Ormiston, and in the Penston and Macmerry district the 3 to 4-in. ironstone above the No. 2 Diamond could easily be taken out with the coal, were there a market for it near at hand.

South of Pencaitland and Ormiston the bands are very impersistent.

On the west side of the Midlothian basin the Corbie Coals are tentatively taken as the equivalent of the Kailblades and Little Splint, but there is no ironstone on that horizon.

A table of comparative sections is given below.

<i>Cowden.</i>			<i>Carberry.</i>		
	Ft.	In.		Ft.	In.
CLAYBAND	0	3	IRONSTONE	0	4
KAILBLADES COAL	1	3	COAL	0	5
Sandstone	2	1	Fakes	10	3
LITTLE SPLINT COAL	2	1	COAL (KAILBLADES)		

<i>Dolphington.</i>			<i>Penston and St Germain's.</i>		
	Ft.	In.		Ft.	In.
Blaes			Blaes and balls		
CLAYBAND, good	0	4	CLAYBAND	0	4
SPLINT COAL	1	3	Blaes	0	7
BROWN COAL, poor	0	10	COAL	1	4
			WILD PARROT	2 in. to	0
			COAL	1	0
			Fireclay Pavement		

Stoney Coal.—At Loanhead and Roslin there is an ironstone between the parrot and the rough coal sections of this seam. At Roslin it varies from $1\frac{1}{2}$ to 6 in. in thickness. Sections at Loanhead and Burghlee are given below. Should the parrot coal be worked at any future date the ironstone would undoubtedly be of value, especially in the Burghlee workings. The parrot portion of the seam at Burghlee is of exceptionally good quality. Were only the rough

coal worked it would probably be necessary to leave the ironstone as the roof.

	Loanhead.		Burghlee.		Ft.	In.
	Ft.	In.	Cross-cut at 150 fms.			
Blaes roof						
PARROT	0	4	PARROT		1	3
WILD PARROT	0	4	CLAYBAND IRONSTONE		0	7
IRONSTONE	0	4	COAL, Rough		2	9
COAL	1	2				
Sandstone	0	1 $\frac{1}{4}$				
COAL	1	1				
Sandstone	0	1 $\frac{1}{2}$				
COAL	1	0				
Sandstone pavement						

The *Beggar Coal*, on the east side of the basin, may be near this horizon. Sections through its position at Dolphington (Haddington, 9 N.W.) are given under the Penston Ironstone in the sequel. No ironstone is found with this coal at Prestongrange or at Wallyford, however. The scantiness of the information makes it impossible to come to any conclusion regarding this ironstone.

*Loanhead No. 1 Ironstone** (see Fig. 15).—This ironstone is the lowest workable one in the Limestone Coal Group of Midlothian; and at Gilmerton and Loanhead, where it attains its maximum development, it lies about $16\frac{1}{2}$ ft. below the Glass Coal, and $7\frac{1}{2}$ ft. above the Browns Coal. The comparative sections given below show how it deteriorates both to north and south.

In sinking the Niddrie No. 13 Pit a 9-in. blackband ironstone was found between the Stinkie or Peacock Coal and the Little Splint, and this seam, if not exactly on the same horizon as the No. 1 Ironstone, is certainly near to it. The correlation of the Niddrie and Loanhead seams, however, is still somewhat doubtful. Further south, across the Drum Fault, in the Gilmerton field, a section of the No. 1 Ironstone was exposed in the Old Square Pit at Gilmerton Railway Station (Edin., 8 N.W.), and it is reported to have been of as good quality as in the Glasgow Iron Company's workings further south. Other reports, however, say that it was poor. Only the coals were worked here. The shaft was about 95 fms. deep to the Stairhead Coal, and from this level a cross-cut driven west reached the Andrews or Peacocktail Coal. The Gillespie, Blackchapel and Corbie Craig seams were worked, but only to a small extent. The workings reached what was probably the Drum Fault to the north.

The Glasgow Iron & Steel Company's workings were a short distance to the south-west. Their No. 22 Mine, an incline on the No. 1 Ironstone from the outcrop, was put down immediately to the south of the Edinburgh-Lasswade Road, and about 120 yds. N.W. of the railway. It reached a depth of 60 fms., and was in operation from 1872 till 1875, at which date it was abandoned, on account of a heavy influx of water at the north end of the workings. The Ironstone was worked stoop and room, and from the surface to a depth of about 150 ft. it was entirely extracted, for a distance of about 1100 ft. from the incline both to N. and S. Below this level, to the foot of the incline, there is an area about half the size of the pre-

* See also "Geology of Edinburgh District," *Memo. Geol. Surv.*, 1910, pp. 202, 206, 341.

ceding one in which the stoops have not been removed. The Ironstone dips to the S.E. at an angle of 49° and, as shown in the section below, is 26 in. thick. It is reported to have been of good quality. The holing was done in the 6-in. daugh band in the roof.

Towards the east the seam thins out in a comparatively short distance. In the Melville Grange diamond bore, about half a mile east of the outcrop, one or two thin bands of ironstone were found at a depth of between 420 and 430 fms. from the surface, and about 90 fms. below the Index Limestone. One of these probably corresponds to the No. 1 Ironstone. An analysis of one of these bands, 2 in. thick, gave—

Calcined Ironstone.

Per cent.

Fe_2O_3	58.30		
MnO	1.59		Per cent.
CaO	3.42	Fe	40.81
MgO	8.66	S	0.26
Al_2O_3	13.20	P	0.637
SiO_2	14.83		
P_2O_5	1.46		
SO_3	0.65		

Going south along the outcrop, we come to the conjectural position of the Sheriffhall Fault, about 400 ft. from the old workings, and beyond this, for a distance of about 2000 ft. along the strike, the No. 1 seam has not been touched, and its condition is unknown. The metals are still dipping steeply to the S.E., and are cut off on the south by a dip fault with upthrow to the south. This area has probably been left untouched in the past because of the water which it holds back on the south.

This brings us into the Edgefield area (Edin., 8 S.W.), about 500 ft. in length at the outcrop, but with the faults on either side diverging rapidly towards the dip. In this section, the No. 1 Ironstone has been all worked out to a depth of 50 fms. by the Shotts Iron Co., but below that it is standing solid, and is reported to be of good quality and thickness. This is especially probable since the proved ironstone immediately to the south is workable to a depth of at least 200 fms. vertically. This is in the Ramsay Pit field of the Shotts Iron Company, and is reached from the Edgefield area through an upthrow fault with apparent horizontal displacement of about 500 ft. This area measures 4000 ft. along the outcrop, and has been worked out to a depth of 100 fms. vertically. Below this it is untouched and of excellent quality, but mining is hindered by the fact that most of the area is under the town of Loanhead, and considerable damage would be done to property by subsidence, if the seam were worked. This would apply to a depth of, say, 200 fms. At greater depths it might be possible to take out the ironstone, should it be found of workable proportions. It has never been prospected in depth, but with such a proportionately large extent of productive outcrop there is likely to be a considerable reserve to the dip. The seam flattens out at a depth of about 250 to 300 fms.

To the south-west of the Ramsay Pit workings we pass through an upthrow fault with apparent horizontal displacement of about 150 ft. into the Burghlee Field (Edin., 7 S.E.), which runs south-west for a little over a mile, to the Roslin Road fault. It will be noticed,

by comparing the sections of the seam in the various areas with one another, that it deteriorates to the south-west. The clayband in the roof has quite died out before the Roslin Road fault is reached, and when we cross this we find only thin and worthless ironstone bands marking the horizon in the Roslin field. Nor does it again improve in quality to the south, where the position is exposed at Mauricewood and at Brunston, but with no ironstone.

In the Burghlee field the seam has been almost completely worked out to a depth of 200 fms. vertically. Below this it has not been proved. The average dip of the seams here is about 56° S.E., flattening out between 250 and 300 fms. in depth to a dip of from 5° to 7° , and continuing into the centre of the Midlothian basin in broad undulations. The possibilities of this seam beyond the limits of the present and former workings may be discussed under the headings of the different areas.

(1) *Gilmerton*.—The exposure in the Old Square Pit, coupled with the proved area in the Glasgow Iron & Steel Co.'s workings extending along the outcrop for about a third of a mile, makes it probable that the Ironstone is workable from the Edinburgh-Eskbank road to the assumed position of the Sheriffhall fault, or for a distance of about a mile along the outcrop. A width of about 600 ft. from the outcrop towards the dip may therefore be taken as probable reserves, which at an inclination of 50° gives 480,000 tons under $49\frac{1}{2}$ acres. A further area to the dip of about 58 acres, yielding 561,000 tons, may be taken as possible. Beyond this we can say nothing, as the depth would be nearly 400 fms., and the seam was not found of value in the Gilmerton Melville bore, to the east.

(2) *Sheriffhall Fault—Edgefield*.—Though nothing appears to have been done in the way of proving this field, the quality of the Ironstone both to north and south leads us to infer a possible reserve of about 313,000 tons under 43 acres, calculated to a depth of 200 fms. vertically, at a dip of 50° .

(3) *Edgefield*.—Since the Ironstone was found workable from the surface to a depth of 50 fms., and since the quality is maintained in depth immediately to the south of the area, a probable reserve of about 222,000 tons under $30\frac{1}{2}$ acres has been assumed—from a depth of 5 to 200 fms. vertically. The inclination would probably be 60° or greater.

(4) *Ramsay Pit*.—Here, as stated above, the seam has been worked to a depth of 100 fms., and the next 100 fms. below is not obtainable at present. Below this, from 200 fms. to 250 fms., about which depth the seam flattens out, we may take the Ironstone as probably of good quality, giving 165,000 tons under $22\frac{1}{2}$ acres, at a dip of 50° . Beyond this, on the flat, there is a possible reserve of about 515,000 tons in 110 acres at somewhere between 250 and 300 fms. from the surface.

(5) *Burghlee Pit*.—About 90,000 tons of proved ironstone are still left above 200 fms. in vertical depth. Below this, in the unproved ground, we may take about 200,000 tons to be probable reserves in the area from 200 to 250 fms. under 28 acres. Below this, on the flat, an area of 150 acres, containing 702,000 tons, has been taken as possible. This is, to a large extent, based upon the probability that a breadth of half a mile (half of which has been proved) is not too much to assume on a proved productive length of outcrop of nearly 3 miles.

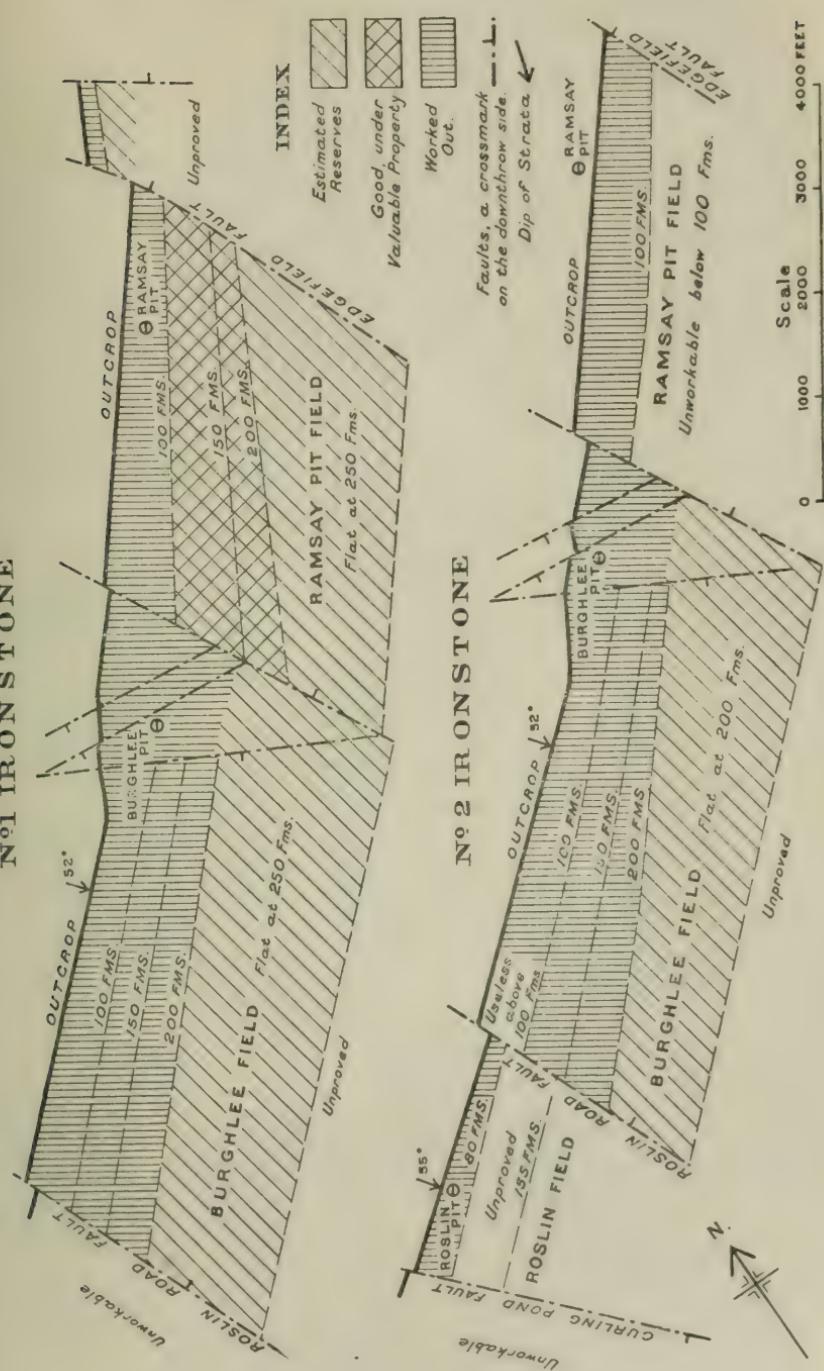


FIG. 15.—Plans of Nos. 1 and 2 Ironstones, Loanhead.

The following analyses of the Loanhead No. 1 Ironstone have been kindly furnished by the Shotts Iron Co. Ltd.:-

No. 1 Ironstone, Dryden.

(1)	Sample from No. 2 Incline.	Section 18 in.	
(2)	"	5 in.	
(3)	"	Cross-cut from No. 1 Incline.	Complete section.
		(1) Per cent.	(2) Per cent.
		(3) Per cent.	
SiO ₂	.	3·85	9·60
Fe ₂ O ₃	.	41·39	45·80
FeCO ₃	.	.	60·67
MnO	.	.85	1·07
Al ₂ O ₃	.	.95	4·57
CaO	.	1·75	3·12
MgO	.	1·45	4·30
P ₂ O ₅	.	.70	1·14
S	.	.82	.25
Volatile	.	.	10·54
Fixed carbon	.	.	9·66
Fe in raw ore	.	28·97	32·05
Fe in calcined ore	.	56·71	46·16
P in calcined ore	.	.58	.70
Loss on calcining	.	48·92	30·57
			43·29

No. 1 Ironstone, Loanhead.

(a) Top ply Clayband, 6 in. (b) Middle ply Blackband, 5 in. (c) Bottom ply Blackband, 6 in.

	(a) Per cent.	(b) Per cent.	(c) Per cent.
SiO ₂	2·99	5·29	1·82
FeCO ₃	70·63	61·60	69·56
MnO	1·34	1·38	1·02
Al ₂ O ₃	1·10	1·87	0·69
CaCO ₃	5·43	4·64	4·85
MgCO ₃	6·47	5·10	4·26
P ₂ O ₅	1·07	1·21	1·09
S	.29	.38	.47
Coaly matter	10·68	19·53	15·28
Fe in raw ore	34·10	29·74	33·58
Fe in calcined ore	55·32	52·49	57·12
P in calcined ore	.76	.92	.79
Loss on calcining	38·38	43·35	41·22

Sections of No. 1 Ironstone.

Cross-cut in Old Square Pit at Gilmerton.	No. 22 Mine, Gilmerton.	Dryden March, Loanhead.
Ft. In.	Ft. In.	Ft. In.
Clay . 0 2	Blaes . 6 0	CLAYBAND . 0 5
PARROT . 1 ft. to 1 3	Daugh . 0 6	WILD PARROT . 1 0
BLACKBAND . 2 0	CLAYBAND . 0 6	BLACKBAND . 1 1½
	BLACKBAND . 1 8	Daugh . 0 3
	Coarse fireclay 6 0	Hard blaes pave- ment

Ramsay Pit.

	Ft. In.	Ft. In.
Blae roof	0 7	Blaes roof
CLAYBAND .	1 3	BLACKBAND . 0 1
WILD PARROT .	1 6	CLAYBAND . 0 4
BLACKBAND .		WILD PARROT . 1 0
		BLACKBAND . 1 3
		Fireclay pavement

Burghlee Pit.

	Ft.	In.
CLAYBAND	2 to	0 5
Blaes	.	0 6
PARROT	.	1 0
BLACKBAND	.	1 3

430 fms. West from Burghlee Pit.

	Ft.	In.
CLAYBAND	.	0 3
PARROT	.	0 10
BLACKBAND	.	1 1
Clay	.	0 1

Penston Ironstone.—Although the Penston Ironstone mines were working as late as 1880, and at one time had an output of 100 tons per day, we have not been able to obtain much reliable information regarding them.

On the south-east side of the Midlothian basin there is no iron-stone known on the Loanhead No. 1 horizon, but further north, at Dolphington, two ironstones have been found in what is probably very close to the No. 1 position. The two sections below show in detail the strata in the vicinity of the Jewel Coal (Five-foot Coal of Wallyford and Tranent) and the Beggar Coal.

No. 5 Bore, Panwoodlees Field,
Prestongrange.
(Haddington, 9 N.W.)

	Ft.	In.
COAL	.	0 8
BLACK STONE	Penston	1 1
BROWN STONE	Ironstone	1 0
Blaes	.	0 6
Dark blaes.	.	2 11
Sandstone	.	5 1
Whin	.	2 2
Fakes and blaes	.	2 7
Blaes	.	5 0
JEWEL COAL	.	4 2
SOFT COAL	.	0 2
White sandstone	.	4 6
Hard grey sandstone	.	3 1
Fakes and blaes	.	1 4
Blaes	.	1 3
Grey fakes.	.	1 9
Blaes	.	5 3
Fakes and blaes	.	3 8
HARD GREY STONE (Iron-stone)	.	1 3
Fakes	.	1 4
Blaes	.	4 4
COAL	BEGGAR	2 0
Dark blaes	COAL	1 9
COAL	.	3 10

Dolphington Engine Pit.
(Haddington, 9 N.W.)

	Ft.	In.
WILD PARROT	.	0 5
BLACKBAND	Pen-	0 7
Blaes		0 8
GREY IRONSTONE	ston	0 7
Blaes	.	1 0
Fireclay	.	0 5
Fakes	.	6 4
Sandstone	.	7 4
Fakes	.	1 11
Blaes	.	6 3
COAL (JEWEL COAL)	.	4 6
Sandstone	.	3 7
Fakes	.	3 0
Blaes	.	8 9
IRONSTONE (poor)	.	0 4
WILD PARROT	.	1 3
BLACKBAND (regular)	.	0 8
Sandstone.	.	3 0
Blaes	.	4 6
IRONSTONE BALLS	.	1 0
COAL, splint; (BEGGAR COAL)	.	3 6

The top ironstone in the Dolphington Pit section was worked and sent to Macmerry (Haddington, 9 S.E.) to be smelted (at Gladsmuir) along with the Penston Ironstone. A section of the seam as worked gave:—

	Ft.	In.
IRONSTONE BAND (good)	.	0 1½
WILD PARROT	.	0 7
BLACKBAND IRONSTONE	.	0 9
Blaes	.	0 3
CLAYBAND IRONSTONE	.	0 5

The two sections are about 308 yds. apart. In No. 4 bore, Panwoodlees field, about 350 yds. to the west, both the Jewel and

Beggar positions were passed through, but no ironstone is recorded above either. The date of both bores, however, is 1836, so that their reliability is doubtful, and the fact that no ironstone is recorded in No. 4 Bore cannot be taken as conclusive, whilst the correspondence of No. 5 with the Dolphingston section confirms its evidence. Neither at Wallyford nor at Prestongrange is ironstone known in the Penston position, nor is there anything in the Tranent area, about a mile and a half to the east of Dolphingston. At Penston, however, on the east side of the East Lothian basin (Haddington, 9 S.E.), the Ironstone again appears about 12 to 14 ft. above the Five-foot Coal (locally called the Panwood Coal). The seam was discovered at Penston in 1846, and was worked there, and slightly to the north, between the years 1850 and 1880, being smelted at Gladsmuir. It outcrops a short distance to the east of Penston, but is nowhere exposed at present. The sections below give some idea of its composition:—

*Section formerly exposed
at outcrop.*

*Two bores near Penston, 1855–6. Exact
position unknown.*

At 36 ft.

At 13 ft.

	Ft.	In.		Ft.	In.		Ft.	In.
BLACKBAND .	1	2	IRONSTONE .	0	2½	IRONSTONE .	0	3¼
Grey fakes .	0	8	PARROT .	0	3	PARROT .	0	4
Fakes and blaes.	0	10½	Blaes .	0	½	COALY IRON-		
COAL .	0	7½	IRONSTONE .	0	4½	STONE .	0	8½
Various strata .	12	0	COALY IRON-			IRONSTONE .	0	5½
FOUL COAL (= PANWOOD or FIVE-FOOT C.)	1	6	STONE .	0	8	Various strata .	21	0
			Various strata .	17	0	PANWOOD COAL		

No record of the extent of the ironstone workings has been obtained, and possibly the deposit was almost worked out, but it is quite as likely that the stoppage was due to the reduction in price because of the importation of foreign ores. The possible extent of the field is very limited, as there is no trace of the seam in bores at Montfair, about a mile to the west, nor is it known to have been worked north of the Edinburgh-Haddington road. At St. Germain (Haddington, 9 N.W.) it is represented by a 4-in. ironstone band. Towards the south, it is represented by a thin ironstone band at Pencaitland and Ormiston. Several bores between Tyneside and Pencaitland show from 4 in. to 11 in. of ironstone in the Penston position, while at Elphinstone there is a coal with ironblaes above it on the same horizon.

The Penston Blackband was of excellent quality, but no idea of the possible reserves can be obtained, as the information regarding the extent of the workings is scanty. It lies flat and very near the surface in the Penston district, and these facts of themselves make it unlikely that there is much left.

At Dolphingston it would average 40 to 60 fms. in depth, with several workable coals quite near it, but we are ignorant with regard to its behaviour laterally.

An analysis of blackband from the old furnaces at Macmerry (Gladsmuir) gave as follows: *—

* Analysed, T. Robertson, 1918. Geol. Survey Lab., Edinburgh.

	Raw.	Calcined.
	Per cent.	Per cent.
Fe .	29·92	48·82
Insol. .	5·51	9·00
Al ₂ O ₃ .	7·04	11·48
CaO .	4·06	6·63
MgO .	nil.	nil.
S .	1·20	?
P .	0·86	1·25
Loss on calcination .	38·71	

It is not certain, however, that this can be taken as representative of the Penston Ironstone as worked.

*Culpatie Coal.**—Returning to the Loanhead district, we find another iron-bearing horizon about 200 ft. higher up in the sequence than the No. 1 Ironstone. It is about 4 ft. below the Blackchapel Coal, and is very variable in character throughout the area. Sections through it give as follows:—

Burghlee Pit. *Loanhead.*

	Ft.	In.		Ft.	In.
Blaes roof			Blaes roof		
IRONSTONE . . .	0	3	CLAYBAND . . .	4 to	0 9
Blaes . . .	0	6	Blaes . . .	1	1
COAL . . .	0	5½	IRONSTONE BALL . . .	0	2
Fireclay pavement			Blaes . . .	0	7
			COAL . . 2 ft. 4 in to	2	6
			Blaes . . .	0	4
			Rock pavement		

Gilmerton-Melville Bore, at 387 fms.

	Ft.	In.
COAL	1	1
Fakes and sandstone	3	11
Blaes	3	8
IRONSTONE	0	5
Blaes	0	8

The ironstone was worked to a small extent at Loanhead, but the coal is of very inferior quality, and worthless at present.

Loanhead No. 2 Ironstone (see Fig. 15).—This is the most important ironstone being wrought at present in the Lothian area. It is situated from 5 to 10 fms. below the Stairhead Coal, and attains a maximum thickness of 2½ feet.

As the various areas into which the Gilmerton, Loanhead and Roslin district is divided by faulting have been described already when considering the No. 1 Ironstone, it will be sufficient to indicate the character of the No. 2 Ironstone in each of these, commencing with the most northerly exposure.

As with the No. 1 Ironstone, the first trace of the No. 2 is found in Niddrie No. 13 shaft, where 7 in. of ironstone is recorded with two thin coals, about 6½ fms. below the Stairhead seam, the inclination being 45° to 50°. This is the only recorded exposure north of Gilmerton, so that we cannot look upon it as having any commercial value.

Passing through the Drum fault, we find, as shown in the section below, that the seam is utterly valueless in the Gilmerton area, there being only a trace of ironstone in the No. 2 position. Besides the

* i.e. Perpetual Coal.

evidence of the Gilmerton-Melville bore, we have a cross-cut driven in the Old Square Pit at Gilmerton Station from the Stairhead to the Peacocktail Seam, and in it no ironstone was found between the Stairhead and Gillespie seams.

Going further south, nothing is known about this horizon until we reach the Ramsay Pit workings. There is almost no hope, however, of workable ironstone being found, as in the Ramsay Pit the No. 2 Ironstone was found to decrease in thickness with depth and to the north and is quite unworkable at the 100-fm. level. Above this it is worked out. The dip is 50° to 60° to east. Immediately above the No. 2 seam in this area is a coal called Charlie's Coal, but as we travel south, the seams gradually become separated by intervening strata until, at Roslin, they are 22½ feet apart.

In the Burghlee Pit the No. 2 Ironstone attains its maximum development and is still dipping sharply to the east. It has been worked out down to the 100-fm. level except at the south-west end of the area where it was too poor to work. Between 100 and 150 fms. it is mostly worked out, but there remains about 30,000 tons still to be taken out. As the workings approach the Roslin Road fault, however, the seam will probably deteriorate as it did above the 100-fm. level. From 150 to 200 fms. the seam improves in thickness, as shown by the comparative sections given below, and it also remains of good quality going south towards the Roslin Road fault. About 65,000 tons still remain at this level.

Below 200 fms. the seam rapidly flattens out. Evidence regarding the area on the flat is supplied by the Mountmarle No. 1 diamond bore, put down about half a mile to the south-east of the surface projection of the 200-fm. level. Here the seam was reached at 250 fms. and was found of good quality and thickness, as shown by the section below. We are therefore safe in assuming a considerable area of productive ground on the flat, and 500,000 tons under 95 acres have been taken as probable reserves, whilst another 230,000 under 44 acres may be looked upon as possible.

To the south-west, the Roslin Road fault brings us through an upthrust with an apparent horizontal displacement of about 200 ft. into the Roslin field. Here the No. 2 Ironstone is still of good quality, as shown by the section below. It has been completely worked out to a depth of 80 fms. It has not been proved at any great depth yet, so no estimate of reserves is possible. It is not being wrought at present, but is soon to be tapped at a depth of 155 fms. The length of the Roslin field at the outcrop is about 2500 ft., diminishing towards the east as the boundary faults come nearer together. The dip is about 55°, and the flattening out occurs sooner than in the Burghlee field, since the Midlothian basin becomes shallower to the south. The No. 2 Ironstone will probably begin to flatten between 150 and 200 fms.

About 1877 the Glasgow Iron Company started working the No. 2 Ironstone in this field, having leased the minerals from Sir Simon Macdonald Lockhart, and they worked it until 1881. They also worked the Rumbles Parrot, above the Great Seam, to some extent between 1876 and 1886.

The ironstone was taken out for a short distance to the south of the Curling Pond Fault, but the worthless area was soon encountered.

An analysis* of the No. 2 Ironstone at Dryden, in the cross-cut, from No. 1 Incline, gave as follows:—

	Per cent.
SiO ₂	8·37
FeCO ₃	48·72
MnO	0·99
Al ₂ O ₃	4·05
CaO	4·98
MgO	4·28
P ₂ O ₅	0·94
S	1·06
Volatile hydrocarbons	16·10
Fixed carbon	12·08
Fe in raw ore	23·52
Fe in calcined ore	44·99
P in calcined ore	0·78
Loss on calcining	47·72

On the south-west side the Roslin field is bounded by the Curling Pond Fault, a downthrow with an apparent horizontal displacement of about 50 ft., and beyond this the No. 2 Ironstone deteriorates rapidly, and is not known to be workable anywhere to the south.

In connection with the No. 2 Ironstone there may be mentioned the existence of a 5-in. band of blackband ironstone which was found in the Cowden shaft at Dalkeith, on the east side of the Midlothian Basin. It lies between the Diamond and Siller Willie Coals, about 2½ ft. below the former, and overlies a coal 22 in. in thickness. It has not been found possible to procure any other information regarding this seam, but it lies almost in the same position as the Loanhead No. 2.

Further north, at Carberry and Wallyford, 4 in. of clayband ironstone were found during sinking operations about 6 fms. below the Great Seam, and this band is exposed in a cross-cut at Wallyford. What is probably the outcrop of this is found in a quarry at St. Clement's Wells, about a mile south-east of Wallyford. This is probably the seam referred to by Mr. Ralph Moore in his paper† before the Royal Scottish Society of Arts in 1860. He mentions that the Carron Company at one time got clayband ironstone at St. Clement's Wells and took it to Carron to be smelted.

It is stated by miners at Wallyford that the 4-in. clayband was carted to Macmerry to be smelted whilst the furnaces there were still in blast, but in what quantity is not known. It cannot possibly have been large.

It is possible that this band is on the same horizon as the 5-in. blackband at Cowden, since it is underlain by about 2 in. of parrot. This correlation is doubtful, however.

Sections of Loanhead No. 2 Ironstone.

Niddrie No. 13 Pit (Edin., 4 S.W.), Gilmerton-Melville Bore (Edin., 8 N.W.),
6½ fms. below Stairhead Coal. at depth of 373 fms.

	Ft.	In.			Ft.	In.
IRONSTONE BALLS	0	2	Blaes . . . . .	. . . . .	3	8
Fakes and blaes	1	4	IRONSTONE . . . . .	. . . . .	0	2
Blaes	1	11	COAL . . . . .	. . . . .	0	4
COAL	0	3	Blaes . . . . .	. . . . .	0	5
IRONSTONE	0	7	COAL . . . . .	. . . . .	0	8
COAL	0	4				
Fireclay						

* Communicated by the Shotts Iron Co. Ltd.

† "On the Blackband Ironstones of the Edinburgh and East Lothian Coal Fields," *Trans. Royal Scot. Soc. Arts*, vol. vi., 1864, pp. 11-24.

Burghlee Pit (Edin., 7 S.E.).

	Ft.	In.
Between 100 and 150 fms.		
CLAYBAND IRONSTONE	0	1
WILD PARROT	0	4
TOP IRONSTONE (B.B.)	0	6
PARROT	0	9
BLACKBAND IRONSTONE	0	6
Fireclay and Coal	1	10
Between 150 and 200 fms.	Ft.	In.
CLAYBAND IRONSTONE	0	1
WILD PARROT	0	7
TOP IRONSTONE (B.B.)	0	10
PARROT	0	6
BLACKBAND IRONSTONE	0	10½
Fireclay and Coal	1	3

Mountmarle Bore (Edinburgh, 8 S.W.), at 250 fms.

	Ft.	In.
CLAYBAND IRONSTONE	0	2
PARROT	0	4
IRONSTONE, coaly	0	6
BLACKBAND IRONSTONE	0	3
PARROT	0	9
BLACKBAND IRONSTONE	1	2
PARROT	0	5
Blaes	0	8
IRONSTONE	0	1
Dark blaes	1	3
Fireclay	0	11
COAL	1	6

Roslin Colliery (Edinburgh, 7 S.E.), at 80 fms.

	In.
Blaes roof	0
TOP IRONSTONE	5
PARROT	10
BLACKBAND IRONSTONE	12

Roslin Field, South of Curling Pond Fault.

	Ft.	In.
Dirty COAL	0	3
Fireclay	0	9
Dirty COAL	0	8
WILD PARROT and blaes	1	0
Sandy IRONSTONE	0	6
Fireclay	0	9
COAL	0	5
Fireclay and IRONSTONE balls	3	2
COAL	1	9

The quality of the ironstone got from this seam is not recorded.

Stairhead Seam Ironstone.—At Niddrie, a blackband ironstone is found associated with the Stairhead Cannel, and for some time part of this was brought to the surface and sent to Shotts to be smelted. It was chiefly used, however, for building the roads in the seam and only the surplus was sent up. It is purely local in occurrence, and dies out before reaching Brunstane Burn to the

north, nor is it recorded in the Gilmerton-Melville Bore to the south. Comparative sections of the seam are shown below. At Niddrie the Edge Coals strike almost north-and-south, dipping at a high angle to the east, nor do they flatten out in depth until about 400 fms. from the surface. At Niddrie itself there is from 8 to 12 in. of blackband below the cannel, but in depth it practically disappears, degenerating into lenticles and balls. North of a line drawn in a N. 30° W.-S. 30° E. direction, crossing the Stairhead outcrop a short distance south of No. 10 Pit, the Ironstone rapidly deteriorates, disappearing completely at the north end of the workings. South of the line the Ironstone remained of good quality, as far as the southern limits of the workings. It is not recorded in the workings at the Old Square Pit at Gilmerton, nor does it seem to be present in the deeper parts of the field to the S.E., where the position was proved by the Gilmerton-Melville bore.*

The Stairhead Seam at Niddrie was worked for its cannel, but is not being raised at present.† In the event of its being opened up again at any future date, there would still be a fair amount of ironstone obtainable from it, chiefly at the south end of the workings, though it is impossible to estimate the quantity, as much of it would go to the building of packs, unless favourable terms were obtained from the ironmasters.

Two Sections at Niddrie.

(Edinburgh, 4 S.W.)

	Ft.	In.		Ft.	In.
STEAM COAL . . .	1	6	COAL . . .	1	6
CANNEL . . .	2	2	CANNEL . . .	2	0
BLACKBAND IRONSTONE 0	6		BLACKBAND IRON- STONE . . .	4 to 0	8
" (INFERIOR) . . .	0	4	COAL . . .	1	6
ROUGH COAL (steam)	1	6			

Drum.
(Edinburgh, 8 N.W.).

	Ft.	In.
COAL	2	6
BLACKBAND IRONSTONE 0	8	
Blaes : : :	0	8
COAL	1	6

Gilmerton-Melville Bore at 368 fms.
(Edinburgh, 8 N.W.).

	Ft.	In.
Sandstone		
COAL	1	5
PARROT	0	5½
Coaly blaes	0	½
COAL	1	2

Great Seam and No. 3 Ironstones.—The ironstone connected with the Great Seam is much more persistent than that with the Stairhead Seam, and has furnished a large quantity of ore. It is not being worked anywhere at present, however.

To get a coherent idea of how the ironstone on this horizon behaves it were best to commence at the north end of the west side of the Midlothian Basin and travel southwards. The comparative sections below are arranged in that order.

The most northerly exposure, on the railway line just east of Portobello, shows no ironstone, though the parrot, for which the

* For section of Stairhead Coal at Mauricewood, see p. 194.

† It is worked out to a depth of 350 fms. except to the south between Woolmet and Drum, where only 150–200 fms. have been extracted.

seam was worked further south, is present, 1 ft. thick and of good quality.

Passing southwards into the Niddrie field, we find that the iron-stone below the parrot behaves in a manner curiously similar to the Stairhead Ironstone discussed above. The same line on the map* serves to divide the persistent and regular band on the south from the irregular and rapidly dying out lenticles on the north and east.

The seam has been almost all worked out to a depth of 350 fms. from Brunstane Burn on the north to the Drum Fault on the south, and a small area has been taken out at a depth of 430 fms. At this latter depth the dip has flattened out to 12°, and the ironstone has degenerated into balls.

The seam is not being worked at present, as the gas coal was the constituent sought after. The ironstone was chiefly used for road building, though a small percentage was filled. This was mixed with that from the Stairhead seam and sold, mainly to the Shotts Iron Company.

As with the Stairhead, the future of the Great Seam at Niddrie depends upon the economic status of cannel coal, as the parrot portions of both are of excellent quality, though thinning in depth.

The ironstone output from Niddrie was very variable, and finally ceased in 1910. Below are given the figures for several years between 1897 and 1910:—

1897	12,945 tons	1906	10,479 tons
1899	7,906 "	1909	4,940 "
1904	8,348 "	1910	958 "

Evidence in the Gilmerton area is derived from two sources, the Old Square Pit workings and the Gilmerton-Melville Bore. In the former, only a small area of the seam was worked, and that was of common coal. Whether there was ironstone or not is not stated. Had the parrot portion of the seam been of workable thickness it is very unlikely that it would have been left untouched at the time that the pit was working, and the thinning out of the parrot suggests the impoverishment of the accompanying blackband.

In the Gilmerton-Melville bore to the east it will be seen that the ironstone has thinned away to $4\frac{1}{2}$ in., and cannot be taken into account.

There is some reason to suspect that, as we go south, the Great Seam splits into two portions, and that the Rumbles Coal, or No. 3 Ironstone of Loanhead, is in reality the upper portion of the Niddrie Great Seam. So little is known of the horizon in the intervening area that we may pass on to the Loanhead field, where the Rumbles Coal was worked to a considerable extent, both for the ironstone and for the much valued cannel associated with it. The area in which it contains these constituents in workable amount is practically exhausted, however, and the small portion remaining is not likely to be wrought except along with the adjacent coals.

The Wild Parrot or Rhums above the ironstone is fairly persistent, and if it were used for gas-producing purposes, e.g. in a

* The position and direction of the line referred to are described on page 185 under the account of the Stairhead Seam.

producer plant, the ash might possibly be smelted as an iron ore. A commercial analysis* of this bed gave as follows:—

Proximate Analysis.		Analysis of Ash.	
Volatile hydrocarbons	40·79 per cent.	Fe ₂ O ₃	70·83 per cent.
Fixed carbon	19·28 "	CaO	3·71 "
Ash	35·51 "	MgO	0·73 "
Moisture	4·42 "	Insoluble	15·79 "
		S	0·35 "
		P	0·64 "
		Fe	49·53 "

No analysis of the ironstone in the Rumbles Seam as worked at Loanhead is available. As will be seen from the sections, the productive area was to the south of Loanhead, at Dryden; and the ironstone band thins out and practically disappears both laterally and in depth. At the Mountmarle bore it has quite vanished (Edin., 8 S.W.).

In the Roslin field only a thin streak marks the position, and the section found in a bore at Kirkettle about $1\frac{1}{2}$ miles east of the Edinburgh Road at Glencorse, shows only 3 in. of ironstone in the roof of the Rumbles Coal. Elsewhere the position has not been inspected until we cross the 80-fathom Fault, a downthrow to the south, and enter the Greenlaw and Mauricewood areas (Edin., 13 N.E.). Here the outercrop of the Edge Coals has veered round into a N.E.-S.W. direction, and the Rumbles Coal has become a blackband ironstone, and lies only 3 to 4 ft. above the Great Seam. A section through the position is given below. Near the surface the metals dip to the south-east at an angle of about 60° , but further down they become less steep (about 47°). At a vertical depth of 200 fms. they flatten out into the bottom of the basin. The ironstone above a vertical depth of 100 fms. has been almost worked out for a distance of a mile and a half along the outercrop, by the Shotts Iron Co. It was worked from two inclines, one at Greenlaw and one at Mauricewood. The two sections are separated by a powerful dip fault with a downthrow to the S.W. and an apparent horizontal displacement of about 300 ft. In the Greenlaw area almost nothing was done in the basin, as the ironstone is under Government ground at Glencorse Barracks, but between the 100-fm. level and the basin some ground was worked. It was good in depth, however, and may continue so for some distance to the south-east, though it is not recorded in a bore at Kirkettle, 2 miles to the east.

In the Mauricewood area the seam was worked as far south as Cuiken—at the outercrop—and is mostly extracted above the basin. On the flat also a large area has been worked, but much remains in.

The Great Seam † was worked in conjunction with the Ironstone, but not to nearly the same extent.

To the south-west there is no satisfactory evidence to show how far the Ironstone extends. The section at Marfield Quarry, 3 miles S.W. of Penicuik, shows that it has died out.

Above the basin an area of $8\frac{1}{2}$ acres has been taken as probable reserves—giving a tonnage of 68,000. In the basin an area of 385 acres may be looked upon as possible with a tonnage of 1,410,000.

* Analysed by the writer, 1918, Geol. Survey Lab., Edinburgh.

† See also p. 194.

Niddrie.

Section of Great Seam.

	Ft.	In.
COAL	4	to 0 9
PARROT	14	in. to 2 6
IRONSTONE	4	to 0 8
CROW COAL	3	to 0 9
COAL	14	in. to 1 6
Daugh or clay (holing), 4 in. to 1	8	
COAL	2½	to 4 0

*Gilmerton-Melville Bore
(at 362 fms.).*

Section of Great Seam.

	Ft.	In.
FREE COAL	0	7
PARROT	0	2½
FREE COAL	1	2
IRONSTONE	0	3½
IRONY PARROT	0	1
PARROT	0	5½
PARROT (good)	0	5½
FREE COAL	1	3
Fakes	0	4
FREE COAL	2	9

Loanhead.

	Ft.	In.
RUMBLIES	Blaes roof	
PARROT	{ SOFT COAL	1 4
	{ WILD PARROT	0 7
	{ SOFT COAL	1 1
	Various strata	12 0
	GREAT SEAM	

	Ft.	In.
RUMBLIES	Blaes roof	
PARROT	{ WILD PARROT	1 0
	{ IRONSTONE	0 2
	{ PARROT	0 8½
	{ FREE COAL	0 11
	{ COAL	1 3
	{ FREE COAL	0 4
	Various strata	12 0
	GREAT SEAM	

S. of Burghlee Pit.

	Ft.	In.
RUMBLIES	Blaes roof	
PARROT	{ WILD PARROT	1 6
	{ IRONSTONE	0 9
	{ GAS COAL	1 8
	{ IRONSTONE	0 7
	Various strata	18 0
	GREAT SEAM	8 0

*Kirkettle Diamond Bore
(at 143½ fms.).*

	Ft.	In.
IRONSTONE	0	3
Dark blaes	0	6
RUMBLES COAL	2	3
Fireclay	0	5
Various strata	7	3
COAL	0	7
Dark blaes	0	3
COAL	0	6

Mauricewood.

	Ft.	In.
COAL	1	ft. to 1 4
Fireclay and blaes	9	in. to 1 3
BLACKBAND	6	in. to 1 6
Fireclay . . . . .	. . . . .	0 2
Fireclay and balls	2½	to 3 0
Dark blaes	6	to 0 7
TOP COAL . . . . .	. . . . .	2 3
Midstone . . . . .	. . . . .	0 3
BOTTOM COAL . . . . .	. . . . .	2 9

No analysis of this ironstone is available. The sulphur in several samples from Mauricewood varied from 0·65 to 1·11 per cent.

Additional notes on the Mauricewood field will be found in Appendix II., pp. 193–5.

At Wallyford an ironstone band is found in the same position as the No. 3 Ironstone, as shown in the following section:—

	Ft.	In.
Fakes and blaes	3 5
COALY IRONSTONE	0 5
CLEAN IRONSTONE	0 3
Fakes and fireclay	1 9
Gray fakes	3 8
Dark blaes	0 7
GREAT SEAM	10 10

This hints at the possibility of ironstone above the Great Seam in the more central part of the basin. This band, however, has not been found at Carberry, a mile or two further south.

Still higher up in the Edge Coal Group, about 25 ft. below the Index Limestone, an ironstone band is recorded at Newtongrange, where the section is as follows:—

	In.
CANNEL	$2\frac{1}{2}$
IRONSTONE	$3\frac{1}{2}$
COAL	$3\frac{1}{2}$
CANNEL	$7\frac{3}{4}$

There is nothing recorded in the same position at Cowden or Gorebridge, but in a bore at Smeaton (Edin., 8 N.E.) the following section is shown:—

	Fms. Ft. In.
Strata	2 5 2
WILD PARROT COAL	0 1 1
IRONSTONE BAND	0 0 2
Fireclay	0 1 0

A 3-in. band in the same position, but without the accompanying parrot, appears in another bore near by. In other bores in the vicinity it is not recorded.

In the very attenuated Limestone Coal Group strata to the south of Penicuik, on the east of Auchencorth Moss, thin clayband ironstones are found in several bores, but none sufficiently thick or persistent to give hope of an economically productive area.

UPPER LIMESTONE GROUP.

Wood Coal position.—Comparative sections through this horizon which is in the Upper Limestone Group,* between the Extra Limestone and the No. 5 (Calmy or Arden) Limestone, are given below. The Gilmerton one is taken in the railway cutting north of Gilmerton Station. The Wood Coal is very impure here, nor was it considered of any value in the Melville bore, about half a mile to the south, where it was got at a depth of 235 fms. The section at Dryden Bank, to the east of Loanhead, was got from a bore (Dryden Bank bore No. 5) put down in a position which seems to be just behind the No. 5 Limestone. The Wood Coal was got at 14 fms. This coal has been worked at Niddrie, but no ironstone is recorded with it there.

It is hardly likely that the thickness shown at Dryden Bank is other than very local, and it probably needs to be corrected for dip, so that the ironstone on this horizon cannot be considered, on the evidence at present available, as having any potential value.

Gilmerton.

Ft. In.

Blaes with nodular IRON-STONE bands	
CLAYBAND	0 3
Blaes	0 10
CLAYBAND	0 4
Blaes, sandstone and fire-clay	6 6
WOOD COAL	2 3

Melville Diamond Bore.

Ft. In.

Blaes, with IRONSTONE bands	5 $2\frac{1}{2}$
IRONSTONE	0 $3\frac{1}{2}$
Blaes, etc.	1 $9\frac{1}{2}$
Sandstone	7 8
Blaes	0 10
IRONSTONE	0 5
Blaes	0 9
WOOD	
COAL	1 6
COAL	0 4
COAL	1 0

* See "Geology of Neighbourhood of Edinburgh," *Mem. Geol. Surv.*, 1910, pp. 231 seq.

Dryden Bank Bore.

	Ft. In.
Shaly blaes	
IRONSTONE RIB	0 4
Dark blaes	1 8
CLAYBAND	1 6
Black fakes and blaes, etc.	34 7
WOOD { COAL	2 6
COAL { Foul coaly blaes	3 3
COAL	0 11

The only other ironstone recorded in the Upper Limestone Group is in the Lady Victoria shaft at Newtongrange, where at a depth of 100 fms. (219 ft. below the No. 5 Limestone) we have—

	Ft. In.
IRONSTONE	0 3½
SHALE (WILD PARROT)	1 2
COAL	1 5

No particulars are available. The position is probably much below that of the Wood Coal Ironstone.

Millstone Grit.

A nodular calcareous ironstone has been recorded on the shore at Port Seton, in the position of the Roman Cement, a little above the base of the Millstone Grit. It averages about 2 ft. in thickness, but is very impure, and the area covered by it is so small that it cannot be looked upon as of any value whatsoever.

Coal Measures.

In a paper* read before the Royal Scottish Society of Arts in 1860, Mr. Ralph Moore expressed the opinion that the Airdrie Blackband position was to be found near the Jewel Coal of Craighall and Smeaton, and the Lower Slatyband position low down in the Cowpits succession. Dr. R. T. Moore suggests that, taking the Jewel as the equivalent of the Lanarkshire Splint, the Golden Coal might possibly be the representative of the Airdrie Blackband. The lower portion of the Coal Measures has not yet been sufficiently proved. A band of ironstone 5 in. thick, in the middle of the Ell Coal, is recorded from a cross-cut at New Craighall Colliery, but is very impersistent and of no value. It is possible, however, that something may still be found in the Coal Measures when they have been more thoroughly prospected.

APPENDIX I.

FUTURE OF THE GILMERTON COALFIELD.

The Gilmerton field is never again likely to be worked for iron-stone alone, and the factor which will influence future development is the condition of the coals.

Important features are—the high angle of dip; the great depth of

* "On the Blackband Ironstones of the Edinburgh and East Lothian Coal Fields," *Trans. Royal Scot. Soc. Arts*, vol. vi., 1864, pp. 11-24.

the seams in the Melville Estate, immediately to the east; the quality of the water; and the troubled nature of the ground. The irony nature of the water pumped by the Gilmerton Gas Coal Co. Ltd., which worked the upper seams of the Limestone Coal Group at the Old Square Pit near Gilmerton Station, led to the stoppage of mining in 1893. This Company started operations in 1886 by pumping out the Old Square Pit and deepening it by 30 fms., making a total depth of 85 fms. The water pumped, however, had such a deleterious effect upon the Dean Burn, into which it was led by the Burndale Day Level, that they were forced to stop by interdict of the Court of Session. This drawback, however, could probably be overcome as described below in connection with the Mauricewood mine water (p. 194).

Near the surface the whole area is much troubled by faults and wants, but it is likely that in the deeper parts of the basin these will become less serious.

Information regarding the coals is derived from two sources, namely, the old Gilmerton Workings and the Gilmerton-Melville diamond bore, put down at Melville Mains in 1902 by Messrs. Wm. Baird & Co. Ltd., to prove the strata in the Limestone Coal Group (Edin., 8 N.W.).

The following seams* appear to offer distinct possibilities. Their positions are noted on the vertical section sheet (Fig. 14).

North Greens Coal.†—This is in section as follows:—

	Ft. In.
Blaes	
PARROT COAL .	1 4
Hard band	0 6
Fireclay	0 9
PARROT AND ROUGH COAL	3 0

As mentioned on page 169 this seam was worked at the same time as the Gilmerton Ironstone. The parrot portion, though not of the first quality, sold readily at 15s. per ton, whilst the rough coal was of excellent quality. In the position of the Melville bore it must be about 580 fms. deep.

North or Blue Coal.—The two sections given below show this seam near the outcrop, and at a depth of 473 fms.

In both places it is an excellent coal, and was considered the best in the Gilmerton Field.

Gilmerton.

	Ft. In.
Blaes	
CANNEL FIR OR ROOF COAL .	1 3
Soft black blaes	1 3
FREE COAL	0 6
SPLINT COAL	0 9
FREE COAL	0 4
SPLINT COAL	0 9
Soft free coal	1 6
Daugh, holing	0 2

Melville.

	Ft. In.
Blaes	
Sandstone fake	5 6
COAL	0 2
FAKE	4 10
	0 7

South or Carleton Coal.—The condition of this seam at Gilmerton is not known, but at Melville it was found at a depth of 467 fms..

* See also under Loanhead No. 1 Ironstone.

† In Lower Limestone Group.

and was a good coal, 4 ft. 5 in. thick. At Loanhead, however, it was of poor quality. It is given as $5\frac{1}{2}$ ft. thick at Gilmerton on the old plans.

Andrews or Peacocktail Coal.—Though poor at Loanhead, this seam was 4 ft. 4 in. to 7 ft. thick at Gilmerton, and of very good quality. In depth, however, it is unsatisfactory, giving the following section at Melville, at a depth of 459 fms.:—

	Ft. In.
Blaes	0 9
COAL	1 5
Sulphur rib	0 1
COAL	0 5
COAL and blaes	0 5
COAL	0 8
Fakes and blaes	6 10

Glass Coal.—In this position also nothing of value is found in the Melville bore, but above 100 fms. it is a fairly good coal about $3\frac{1}{2}$ ft. thick. Further south, at Loanhead, it is of good quality.

Stinkie or Peacock Coal.—This coal, though not worked in recent times, was reported to be a fairly good steam coal about 3 ft. thick when last exposed at Gilmerton in the Old Square Pit. In the Melville bore, at 395 fms., there is a 13-in. coal which may represent the Stinkie. No workable coal was found near this horizon.

Gillespie Seam.—In the Gilmerton Gas Coal Company's workings this was a good household coal about 3 ft. thick. At Loanhead it shows the following section:—

	Ft. In.
Sandstone roof	
Blaes	0 10
COAL	3 0
Fireclay pavement	

It is recorded at 376 fms. at Melville, where the section was:—

	Ft. In.
Fakes and sandstone	
Blaes	0 10 $\frac{1}{2}$
Parrotty blaes	0 0 $\frac{1}{2}$
COAL	2 9
COAL, SPLINT	0 3
Fakes	0 2
Sandstone	

It was not considered to be of the best quality there.

*Stairhead Seam.**—This seam was worked at the Old Square Pit, and was said to have a thickness of 3 ft. 2 in. and to be of good quality. At Melville it was 368 fms. deep, and showed the following section:—

	Ft. In.
Sandstone roof	
COAL	1 5
PARROT	0 5 $\frac{1}{2}$
Coaly blaes	0 0 $\frac{1}{2}$
COAL	1 2

Further south, in the Loanhead area, it is of poor quality.

Great Seam.—This seam was also worked from the Old Square Pit, where the width of working appears to have been about 4 ft. The parrot portion does not seem to have been of importance here.

* See also p. 185.

In the Melville bore (see section on p. 188) it was got at a depth of 362 fms., but was not considered of much importance, because of the numerous partings of parrot between the free coal leaves. Nearer the surface, however, it might offer better prospects.

From the above it appears that there are several good coals in the Edge Coal Group at Gilmerton, though most of them, except the North and South Coals, deteriorate in depth. They are dipping at a high angle, and are for the most part standing solid below a depth of 50 fms. The maximum amount of water likely to be met with is about 500 gallons per minute.

APPENDIX II.

FUTURE OF THE MAURICEWOOD COALFIELD.

As noted above (p. 187) the Great Seam was worked at the same time as the Ironstone below the Ironstone waste. Besides these seams, two other coals were wrought to a very small extent between 1891 and 1893, namely, the Union Coal and the Waverley Coal. They are both about $3\frac{1}{2}$ ft. in thickness and 18 ft. apart. The lower one, the Union, lies 50 ft. above the Great Seam, and is possibly the Flex Coal of Loanhead. These were both worked from the Mauricewood incline. After the property was abandoned by the Shotts Iron Co. in 1897 the coals in the field were worked for some years by Mr. Black.

Since the Ironstone is not thick enough to be worked alone at a profit it is necessary to give some information of the associated coals which could be worked along with it when the field is again opened up, and through the working of which the extraction of the Ironstone could be made profitable. The relative positions of these coals are shown in the vertical section of the Mauricewood field given in Fig. 14.*

The Johnstone, Union, Stairhead, Corbie Jewel and Corbie Splint were worked by Mr. Black.

Corbie Splint.—An average section gave:—

	Ft. In.
Fake roof	
SPLINT COAL	1 10
COMMON COAL	0 8
Hard fireclay pavement	

Holing was done in the bottom of the common coal. The Splint is a good hard coal suitable for gas making and giving a fairly good coke. Ten per cent. dross produced in working.

Corbie Jewel.—This coal gave a section as follows:—

	Ft. In.
Freestone roof	
COAL	4 to 6 0
Fireclay	1 2
Rock	

* See also "Geology of Neighbourhood of Edinburgh," *M.-m. Geol. Surv.*, 1910, p. 211.

The holing was in the bottom of the coal, the fireclay being left as pavement. The coal is a very fine house coal, and was the one principally worked after the field was abandoned by the Shotts Iron Company. Thirty per cent. dross produced in working.

The Peacock Coal is too high in sulphur to be of much value.

Stairhead Seam.—The average section is:—

	Ft. In.
Roof, strong fireclay with ironstone nodules	
FOUL COAL	1 5
Bastard fireclay (very strong)	1 0
COAL	3 4
Bastard fireclay (strong)	0 11
Rock	

Holing in bottom of lower coal. Lower fireclay left in the pavement.

This coal is said to coke well, and makes a good furnace coal. About 50 per cent. dross produced.

Great Seam.—This varied considerably, as shown by the three sections below; number (2) is a section of the seam as worked by the Shotts Iron Company:—

(1)	Ft. In.	(2)	Ft. In.
Dark blaes roof, 6 in. to 0	7	Hard fireclay	0 6
TOP COAL	2 3	COAL	0 9
Midstone	0 3	Hard fireclay	0 6
BOTTOM COAL	2 9	COAL	3 0
		Sandstone	
(3)		Ft. In.	
Dark blaes	6 in. to 0	7	
FREE COAL	1 0		
Hard fireclay	0 9		
FREE COAL	0 9		
Hard fireclay	2 6		
FREE COAL	2 6		
Hard sandstone			

It is believed to be of fair quality but high in ash. No particulars have been obtained.

The *Waverley* and *Union Coals* were worked to such a small extent that little is known definitely about them.

The method of working was, in each case, longwall.

From the foregoing it will be seen that there is a sufficient number of workable coals in the field to make the working of the ironstone profitable. The strata are unfortunately somewhat cut up by faults, but not to a prohibitive extent.

Another difficulty is to be found in the quality of the water pumped. The quantity was not a serious matter when the Mauricewood Pit was working last, being about 200 gallons per minute, but it was so heavily charged with iron carbonate in solution that it required to be treated, as the River Esk, into which it was discharged, is used further down by paper mills.

The untreated water contained 125 grains of iron per gallon, but by treatment with slaked lime this was reduced to from 2 to 3 grains per gallon,

Three settling ponds were arranged in series, each of slightly greater capacity than one day's supply of water. Thus the water was over three days in the ponds. The lime was added before the water entered the ponds, about 15 cwt. being used per day.

ESTIMATED RESERVES IN MIDLOTHIAN.

Name of Seam.	For Description see	Area in Acres.	Reserves in Tons.		
			Proved.	Probable.	Possible.
(1) Limestone Coal Group.					
Great Seam Ironstone (Blackband above Great Seam Coal, Mauricewood)	pp. 185-8	8½	...	68,400	...
Do. do.	pp. do.	385	...	...	1,410,000
Loanhead No. 2 (Blackband) Ironstone	pp. 181-4	13	95,000	...	...
Do. do.	pp. do.	96	...	500,000	...
Do. do.	pp. do.	44	...	...	228,000
Loanhead No. 1 (Clayband and Blackband) Ironstone	pp. 174-9	12½	90,000	...	...
Do. do.	pp. do.	131	...	1,073,600	..
Do. do.	pp. do.	361	...	...	2,090,900
(2) Lower Limestone Group.					
Gilmerton Blackband	pp. 169-71	116½	...	475,400	...
Do. do.	pp. do.	225	...	...	917,200
Totals . .	...	...	185,000	2,117,400	4,646,100

CHAPTER VI.

BEDDED ORES OF JURASSIC AGE.

RAASAY IRONSTONE.

THE Raasay Ironstone * belongs to the lower portion of the Upper Lias. Fossil evidence obtained in 1913 by the Geological Survey enabled Mr. S. S. Buckman to show that the ironstone was formed about the time of the Subcarinatum zone or a little later, while other fossils of earlier Upper Lias zones, which are included in it, are derived. Its position relatively to the Jurassic rocks of the district is shown in the accompanying geological map (Fig. 16). The presence of ironstone of economic value in Raasay was discovered by the late H. B. Woodward in 1893 † during his survey of the Jurassic rocks of the island. At the time, no zonal fossils were known from the ironstone; consequently, reasoning from analogy, Woodward estimated that the seam was on a horizon corresponding approximately with that of the Cleveland ironstone.

Exposures are few, restricted in extent, and might easily be overlooked; their discovery is a proof of great patience and acumen on the part of the late H. B. Woodward. The original mapping of the island by him shows the outcrop of the Upper Lias, but he was not in a position to ascertain the full details of the ironstone bed, which is almost everywhere hidden by vegetation or superficial materials. Our present knowledge of the seam is due to the enterprise of Mr. W. Thorneycroft, who surveyed the ground from the mining engineer's point of view. In this exploration, which took place in 1910, he had the help of a mining engineer, Mr. A. F. Campbell, and of Mr. C. B. Wedd. Numerous bores and trial excavations were made, and from these accurate data were obtained. It may be stated here that Woodward's boundary line for the Upper Lias was found to be remarkably correct, the only change of importance being the discovery of an additional faulted area in a peat-covered and obscure portion of the field. The results of Mr. Thorneycroft's investigations are embodied in a paper which he read before the Geological Society of Edinburgh.‡

Over the workable portion of the field the section of the seam and associated strata is generally as follows:—

* A memoir on the Secondary Rocks of Raasay and Skye, by Dr. G. W. Lee, containing a full description of the ironstone field, is in preparation.

† *Geol. Mag.* for 1893, p. 493.

‡ "Note on the Upper Lias of the Western Islands in Reference to the Iron Ore Deposit therein," by Wallace Thorneycroft, *Trans. Geol. Soc. Edin.*, vol. x., Part II., 1914, p. 196.

		Ft.	In.
Dark micaceous shales		30 to 80	0
Hard rib		0	3
IRONSTONE		8	0
Calcareous oolitic shale		2 to 8	0

It is not certain whether a thickness of 17 ft. recorded in one bore is to be regarded as a true thickness; it might be due to the action of faulting. Along the eastern margin of the field, running due north from Hallaig, the thickness is much reduced, and the stone disappears altogether north-east of Dun Caan. The nature of the ore in that north-eastern area is also different, and will be referred to later. In the productive area the stone is in layers a few inches thick, separated by partings. The base consists of dark shaly compact layers with numerous fossils. The bulk of the seam is markedly oolitic. Macroscopic examination shows it to be composed of echinodermic limestone serving as matrix to the ooliths. These generally occur crowded together in thin irregular bands. Of these bands some are—on fresh surfaces—dark glossy green, while others are pale, lustreless green. Short exposure to atmospheric action brings rapid decomposition: the rock becomes brown and spongy, and the ooliths drop out of their sockets. The fossils are chiefly belemnites, with a few ammonites, and are not transformed into iron ore. Some were observed which suggest a *remanié* condition, appearing rounded, corroded and broken. The typical iron ore has also sometimes a breccia-like appearance due to the presence of dark angular fragments similar in composition to the dark compact shale at the bottom of the seam.

The structure of the ore varies within short distances; the markedly oolitic portions characterised by crowded layers of ooliths in a limestone matrix pass into portions with few ooliths embedded in a dark ferruginous matrix. These two types can be recognised with the naked eye, but it needs the microscope to show the differences clearly. Where the seam is of the markedly oolitic type, microscopic examination of the rock together with the comparison of the analyses of the rock in bulk and of the ooliths respectively, show that all the iron is concentrated in the ooliths. The identification of the oolitic mineral therefore shows the place which the ore is to take in the mineralogical classification.

An analysis of the green mineral of the ooliths was made by Mr. E. G. Radley, in the Geological Survey laboratory. The material analysed consisted of ooliths handpicked from the rock, and was free from adhering matrix fragments. An analysis of the rock in bulk was also made by Mr. Radley from the same specimen. The latter had been selected owing to the facility with which the ooliths could be extracted from it, and is not to be regarded as typical of the seam as a whole.

	Ooliths handpicked from the Rock.		Rock in Bulk.
	Per cent.	Per cent.	Per cent.
SiO ₂	20·62	8·58
TiO ₂	0·72	0·28
Al ₂ O ₃	11·96	4·24
Fe ₂ O ₃	5·11	1·24
Cr ₂ O ₃	nt. fd.	nt. fd.
FeO	25·98	11·79
MnO	0·30	0·65

Ooliths handpicked from the Rock.			Rock in Bulk.
	Per cent.		Per cent.
(CoNi)O . . .	0·06		0·04
BaO . . .	nt. fd.		nt. fd.
CaO . . .	11·50		35·43
MgO . . .	3·07		1·71
K ₂ O . . .	nt. fd.		0·02
Na ₂ O . . .	0·09		0·08
Li ₂ O . . .	nt. fd.		nt. fd.
H ₂ O at 105° C. . .	2·56		1·37
H ₂ O above " . .	8·36		4·44
P ₂ O ₅ . . .	5·11		1·68
FeS ₂ . . .	0·71		0·72
Fe ₇ S ₈ . . .	nt. fd.		0·15
SO ₃ . . .	nt. fd.		0·15
C . . .	0·25		0·26
CO ₂ . . .	3·94		27·54
Total . . .	100·35		100·37

An analysis of a typical *average* sample of the proved ore clear of the outcrop was published by Mr. Thorneycroft,* and may be quoted here:

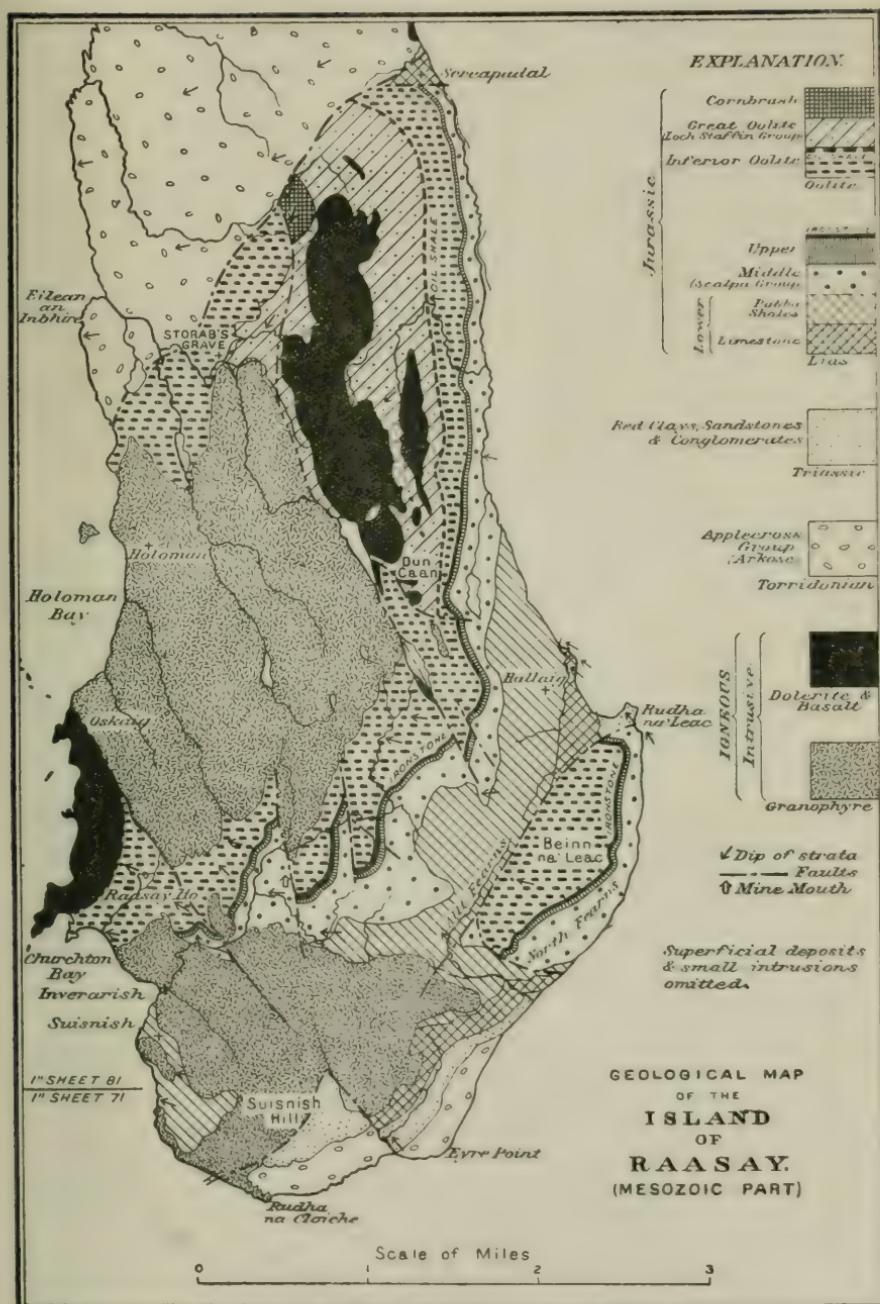
	Per cent.
Ferrous oxide . . .	30·3
Ferric oxide . . .	2·3
Manganese oxide . . .	0·4
Alumina . . .	5·6
Lime . . .	17·6
Magnesia . . .	2·0
Carbon dioxide . . .	28·3
Silica . . .	6·5
Sulphur . . .	0·2
Phosphoric acid . . .	2·3
Water, etc. . .	4·5
Iron in raw stone . . .	25·2
Loss by calcining . . .	29·5
Iron in calcined stone . . .	35·7
Specific gravity . . .	2·83

From analytical considerations it may be concluded that the primary constituent of the green ooliths is a hydrous silicate of ferrous iron, alumina and magnesia. This is referred to the mineral chamosite, of composition H₆(Fe Mg)₃ Al₂ Si₂ O₁₃, and usually included in the chlorite group of minerals. While in the area which is now being opened up chamosite constitutes the bulk of the ooliths, there are at the same time indications that siderite replaces chamosite to a small extent in some of the ooliths. That replacement attains a maximum in samples obtained from the north-eastern edge of the outcrop, that is, north-east of Dun Caan, and also in samples collected in Skye. At both localities the ooliths consist almost exclusively of siderite, and it is only here and there that traces of the original silicate can be detected.

The Ironstone Field.—The distribution of the Upper Lias is so plainly shown on the accompanying map (Fig. 16) that little additional explanation is necessary beyond indications regarding the development of the ironstone seam.

There are two areas containing the formation. The principal

* "Note on the Upper Lias of the Western Islands in Reference to the Iron Ore Deposit therein," by Wallace Thorneycroft, *Trans. Geol. Soc., Edin.*, vol. x. Part II., 1914, p. 200.



one lies north of a line which joins Churchton on the west to Hallaig on the east. In that area the dip is generally a little to the north of west, and amounts to about 10 degrees. The Upper Lias is there overlain by the Inferior Oolite, over 600 ft. thick, which in its turn is overlain by the Great Estuarian Series throughout its eastern half, and by a granophyre sill throughout most of its western half.

The second, and smaller, Upper Lias area underlies the Inferior Oolite of the faulted outlier of Beinn na' Leac.

The ironstone was proved to be of workable thickness, namely about 8 ft., from Churchton to near the path above Hallaig. North of that point the thickness rapidly diminishes, and the green ore gives place to the low-grade carbonate ore described above. All the boring was done within 600 ft. of the approximate line of crop, with the exception of a deeper bore on the shore at Churchton. No boring was done through the concealed field which lies north of the proved area. Of that field, therefore, nothing is known except its eastern outercrop of thinning out low-grade ore. The Beinn na' Leac outlier was tested by a trench above Rudha na' Leac, where the ore was found to be of full thickness; and south of that point the presence of the seam is indicated by loose blocks of the ore.

To estimate the reserves of the Raasay Ironstone amounts to an estimate of the workable area, without deduction for worked-out material, since mining operations have only just started.

As stated above, the boring tests were all made within a short distance of the crop, so that the state of the field to the north is unknown except at its crop to the east. If we assume that the nature of the seam remains constant from east to west, the workable main field would be included between the southern crop and a line running westwards from the path above Hallaig (where the seam begins to thin out). That workable field could be divided into two portions merging into each other: the one nearest to the crop can be taken to have the average thickness of 8 ft. as proved by the borings, while the portion north of it might, for the purpose of calculation, be taken to have a thickness of 5 ft.

The respective areas would be as follows:—370 acres is about the area of the proved belt from Churchton to the path above Hallaig; the Beinn na' Leac outlier is about 300 acres in extent, but allowing for the faulted margins, 250 acres is a safer reckoning from the mining point of view; and 300 acres could be allotted to the thinner belt north of the proved area.

At 27,168 tons per acre the proved area would contain reserves amounting to 10,052,160 tons, and the Beinn na' Leac outlier 6,792,000 tons. At 16,980 tons per acre the thinner zone would hold in reserve some 5,094,000 tons. In these figures possible reserves under the sea west of Churchton are not counted. As stated above, we are in total ignorance of the nature of the seam to the dip under the granophyre sill, and no attempt at estimating the yield of that area would serve any purpose. Indeed, inferences drawn from the eastern crop do not warrant the assumption of any large hidden reserves.

One of the principal features of Raasay as a source of ironstone is the ready accessibility of the seam. The long line of crop, rising steadily from S.W. to N.E., permits of a rapid mode of exploitation.

Were it necessary, a large number of adits could be driven in without pumping machinery. At present the main mine is supplemented by opencast workings a few hundred yards to the east of it, in the faulted patch at the middle of the southern edge of the field, in which much of the ironstone is in the peroxide state.

Raasay Ironstone Horizon in other Scottish Districts.

Owing to the importance of the Raasay ironstone deposit, it may not be out of place to give here a brief account of the Upper Lias in the other Jurassic areas of Scotland. Enquiries are sometimes made as to whether the ironstone is represented in these Upper Lias strata, and it can be asserted that there is no ready supply of the ironstone outside Raasay. Mr. Thorneycroft has dealt with the subject in his paper already quoted, and his views are in harmony with those of the present writer.

At Carsaig, in the south of the Island of Mull, there is a small tract of Upper Lias, with no indications of ironstone. Beyond quite thin ribs and nodules of clay ironstone there is likewise no iron ore deposit in the Upper Lias of the south-east part of Mull, namely, between Loch Buie and Loch Spelve, and in the Loch Don district.

The Kilchoan district of Ardnamurchan was visited in the company of Messrs. Thorneycroft and Wedd, also without results.

In Eigg, the position of the Upper Lias must be at a considerable depth below sea-level.

In the south-east of Skye, the Raasay Ironstone is represented by a ferruginous limestone seen in a section north of Dun Liath.

The Upper Lias is well developed in the north-east of Skye, but where exposed it is unpromising as regards ironstone resources. Near Holm, north of Portree Bay, the Raasay Limestone is replaced by a greenish ferruginous oolitic limestone seen at one or two places in natural sections. It was also pierced in four borings put down by Messrs. Baird. Where best developed it was found to be 5 ft. 9 in. thick, with an iron percentage of 11·96. On the south side of the entrance to Portree Harbour, and further south at Tianavaig Bay, only nodules of ferruginous limestone were observed at the position of the ironstone.

All that remains to consider are the possibilities of the concealed portions of the Upper Lias of North Skye. There is no reason to suppose that the Upper Lias does not extend under the whole of the north of Skye, and ironstone formation, as in Raasay, may conceivably have recurred at various points within that vast tract. Unfortunately, the depth to be expected is everywhere—except in the vicinity of the outer edge—so great that the proving of the field by boring operations would be an expensive matter, and the probability of the development of any ironstone found would be most unlikely under present economic conditions. Taking into consideration only those points where borings could be started in Jurassic rocks beneath the covering of basalt, the least unpromising would probably be the Ollach coast, as it is the nearest to the Raasay field (viz., 1½ miles from Churchton), but in order to reach the Upper Lias the whole thickness of the Inferior Oolite would have to be passed through: a matter of perhaps 100 fms. Going northwards beyond the Holm

district—which has been tested—the depth of the Upper Lias would gradually increase from a few fathoms at Bearreraig to the full thickness of the Inferior Oolite at Inver Tote, beyond which in the direction of Staffin an increasing thickness of Great Estuarine sediments would have to be added. The Upper Lias would thus be some 150 fms. below sea-level at Staffin. A similar estimate applies to the other Jurassic tracts of North Skye, namely, Monkstadt, Uig, and Loch Bay, which were examined by the writer and all found to be high up in the Estuarine Series.

The Upper Lias is nowhere exposed in the Jurassic areas of the East of Scotland, and there is hardly any hope it might be reached by borings of moderate depth. At the most favourable points, namely in the Brora district, the position is concealed through faulting under the whole of the Inferior Oolite and part of the Great Oolite. It is true that we are in ignorance of the nature of the greater part of the sediments of the Inferior Oolite in the East of Scotland, little of which is exposed, but since in that region the Jurassic rocks as a whole are represented by littoral and estuarine deposits of considerable thickness, it seems unlikely that the Inferior Oolite could be less thick here than in Raasay and Skye, viz. about 100 fms. This figure indicates the minimum depth at which the position of the Raasay Ironstone in the Brora district would have to be expected, even if at all present.

CHAPTER VII.

HÆMATITE IN VEINS AND BEDS.

THERE is evidence to show that the occurrence of haematite in veins in Scotland was known from a very early date. In the middle of the 18th century haematite (or limonite) was mined at Tomintoul for a short time: possibly also surface workings were established at the Pennel Burn, Ayrshire, and at Garleton, near Haddington, about the same date. Active exploitation of the veins, however, was practically confined to the period from 1870 to 1885, and the output was never large (see table on p. 15). Most of the known veins, with the possible exception of Tomintoul, are, to all appearance, exhausted, and no mining has been carried on in haematite or limonite veins in Scotland for the last thirty years. The principal producers were Pennel Burn and the Garleton Mine; many of the smaller veins, though repeatedly prospected, have not proved sufficiently attractive to justify serious mining. Consequently, it is not possible to offer any estimates of the ore-reserves in this class of deposit; and it seems likely that the quantities available are too small to affect the general statistics of iron-ore resources in Scotland.

LEICHT MINE, TOMINTOUL, BANFFSHIRE.

One-in. Geological Map, Sheet 75. Six-in. Map, Banffshire, Sheet 144 N.W.
Longitude 3° 15", 40 W.; Latitude 57° 13", 40 N.

This old mine is situated about 5½ miles east-south-east of Tomintoul, in Banffshire, on the west side of the hill known as Carn Liath and on the banks of a small stream which flows south to join the Conglass Water, a tributary of the Avon. The coach road from Strathdon to Tomintoul, which is one of General Wade's military roads, passes the junction of these streams about half a mile south of the mine, and an abandoned cart track connects the mine with this road. The nearest railway station to Tomintoul is Ballindalloch, on the Great North of Scotland Railway, at a distance of 15 miles.

The first attempt to work this vein on a commercial scale was made about the year 1730 by the York Buildings Company.* They erected furnaces at Nethybridge on Speyside, and brought the ore from Leicht Mine to the furnaces on horseback, smelting it with

* W. Cramond : "Notes on the Iron Foundry at Abernethy, Inverness-shire." *Proc. Ant. Soc. Scot.*, vol. xxxi., 1897, p. 226. W. Ferguson : "Notes on some Iron Ore Deposits in Aberdeenshire and Banffshire." *Trans. Geol. Soc., Edin.*, vol. v., 1885, p. 192. Statistical Account of Scotland, vol. xii., 1794, p. 432. New Statistical Account of Scotland, vol. xiii., 1845, p. 298.

charcoal prepared in the extensive woods of Abernethy. In 1737, the works were abandoned, and operations ceased.

About the year 1840, the mine was reopened by Cookson of Newcastle, who sunk a shaft to a depth of 70 or 80 ft. and drove an adit or tunnel westwards from the shaft through the country rock to the banks of the stream. On the opposite side of the stream a mill was erected, the ruins of which are still standing. Water power was obtained by a dam about a quarter of a mile further up the stream and brought to the mill by a lade. The remains of the dam and lade are still visible.

The mineral sought for was manganese ore, which at that time was worth £8 per ton. It formed only a small part of the deposit, and large quantities of siliceous iron ore accumulated on the spoil heaps around the mine. Evidently the ore was broken up by hand and picked: and the old spalling floors are still visible in various places around the dumps, covered with broken manganese ore and limonite. The ore, finally dressed at the mill, was sent on horseback to Speymouth, a distance of 45 miles, where it was shipped. About 1845 manganese ore sunk to £3 per ton, owing to the abundance of foreign supplies, and the mine was abandoned as unprofitable. No particulars are available regarding the amount or value of the ores extracted.

In 1857 the property was inspected by a mining engineer, from whose report we take the following particulars. The vein is in clay-slate, and was explored at a depth of from 20 to 60 ft. for about 250 yards. It varies in breadth from 8 to 20 ft., runs in a direction 25° east of north and west of south, and underlies or dips a little west, as near as can be ascertained about 15°. It contains a large quantity of iron ore intermixed with a good deal of quartz or silica and a little manganese. The workings for manganese have been opened for a distance of half a mile for a depth of 10 ft. At this point the vein is 18 ft. wide, and contains a large quantity of iron ore.

In 1872, analyses of the ore were made by Professor Anderson of Glasgow University. It is stated that the sample was taken from a quantity of 21 tons, from which 3 cwt. were carefully selected so as to represent the average of the whole. The 3 cwt. were broken into pieces the size of walnuts, well mixed, and about 15 lbs. forwarded for analysis. The results were:—

Moisture	1·25
Water in combination	11·41
Peroxide of iron	74·80
Alumina	2·47
Carbonate of lime	trace
Carbonate of magnesia	0·68
Silica	1·23
Phosphorus	0·25
Sulphur	0·18
Sand	7·74
	100·01
Iron in sample as received	52·36
Iron in sample after roasting	59·94

In 1881 the mine was inspected by a mining engineer on behalf of the Shotts Iron Company. He reported that the samples he took

contained iron 46·98 per cent., 52·08 per cent. and 28·65 per cent., the third of these containing manganese 12·48 per cent. No action seems to have been taken as the result of this report.

In 1891, proposals having been brought forward again to open the mine, it was examined by a firm of mining engineers who took samples of the ores and reported to the proprietor, the Duke of Richmond and Gordon, but no attempt was made to start working the deposit.

A little more than 2 miles south of the Leicht Mine on the south side of the pass leading into the Don Valley, on the Allargue Estate, there is a small adit on the side of a stream. It is driven through slaty breccia into an iron-manganese lode, which is apparently a continuation of the Leicht veins. The ruins of an old stone hut adjoin the mine, and there are traces of an open work in brecciated ferruginous veinstone on the west bank of the stream. It is stated that a Glasgow company spent over £3000 in working this deposit, but at what date is unknown.*

In 1917 the mine was visited by Dr. Flett along with Dr. Hatch of the Ministry of Munitions. Dr. Hatch gave instructions to have a trench cut across the outcrop of the vein, and Mr. T. Robertson subsequently collected samples from the rocks exposed in the trench and obtained further particulars of the geology of the deposit. The following notes are based on the results of these investigations.

As shown in the sketch map (Fig. 17) traces of this vein can be observed along a line running S. 15° W., then south and finally south-south-east, for a distance of nearly 4 miles. The outcrop of the vein runs in a narrow and fairly deep valley drained by two small streams which unite to form the Conglass Water. Apparently the course of these valleys has been determined by the belt of brecciated rock in which the iron ores occur. The old mine is situated at the point marked A (Fig. 17), half a mile north of the junction of the streams. The adit has now caved in, and the shaft is no longer open. On the east side of the stream opposite the mill a large spoil heap about 300 ft. long marks the site of the old workings. It consists of slaty phyllite, siliceous limonite, and powdery manganese ore. To the east of this there are three or four pits from 10 to 20 ft. deep which may represent open works, but are also no doubt partly due to the collapse of the old workings. The walls of these pits are mostly covered with heather and grass, but in places considerable masses of quartzose iron ore and rusty breccia may be seen. None of these presents the characters of a useful ore, and apparently they are the valueless parts of the lode left standing by the miners.

The trench cut at Dr. Hatch's instructions was in apparently undisturbed ground to the north of the old workings. On the surface the soil and debris were 4 ft. thick, and the deposit beneath was dug out to a depth of 4 ft. The vein proved to have walls of grey phyllite and to be approximately vertical, but the exact dip could not be measured. Adjacent to the vein the country rock is much broken and mixed with ochreous material. A total breadth of 30 ft. was proved. On the east side there was 15 ft. of lumpy, reddish-brown, siliceous limonite, with an admixture of manganese ore, chiefly

* W. Ferguson, *loc. cit.*

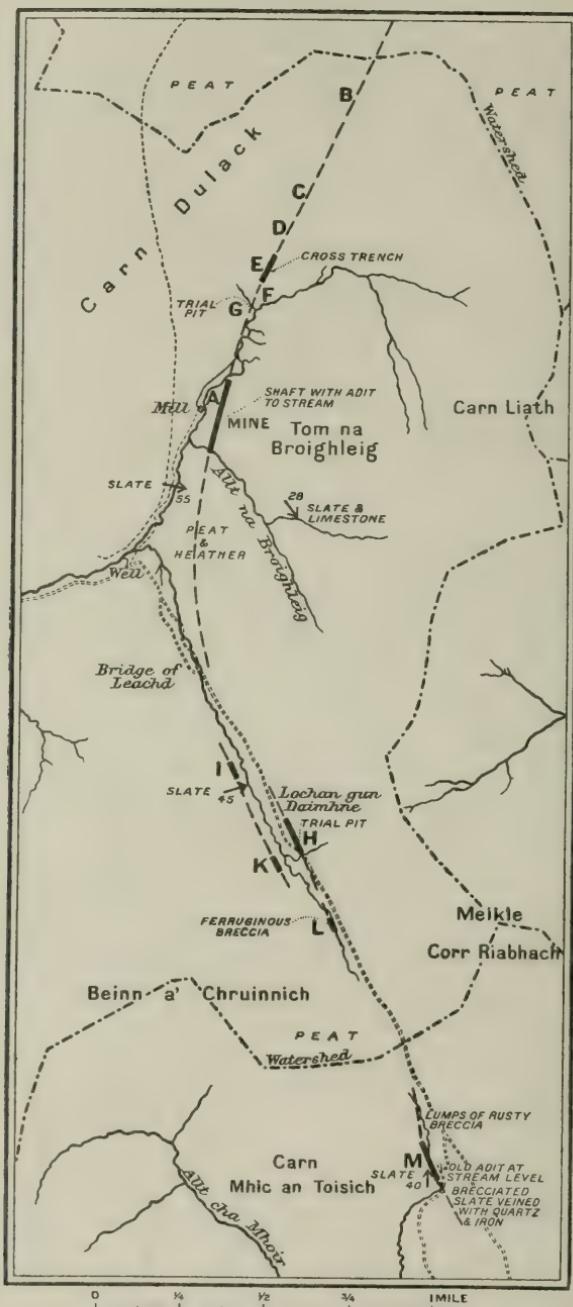


FIG. 17.—The Leicht Iron Ore Vein, Tomintoul, Banffshire.

in patches, the whole being porous and gossany. This material got somewhat compact towards the west, being soft and irregular on the eastern side. It was sampled in two portions each 7½ ft. long, measured across the vein, and marked samples 1 and 2. West of this there was 3 ft. of yellowish, ochreous, lumpy ore (sample 3) passing rapidly into a soft, ochreous breccia very poor in iron, of which there was 12 ft. The western wall of the vein was broken and altered phyllite, which in a few feet passed into the normal phyllite or grey slate of the district.

The analyses of the samples were made at Gartsherrie Iron Works, and are as follows:—

Sample.	No. 1.	No. 2.	No. 3.	No. 4.
	Per cent.	Per cent.	Per cent.	Per cent.
Iron . . .	23·60	36·70	41·90	38·9
Insoluble . . .	55·30	31·40	20·40	5·1
Manganese oxide . . .	1·40	2·10	2·20	9·57
Alumina . . .	2·63	3·33	4·39	...
Lime . . .	0·08	0·18	0·11	Nil
Magnesia . . .	Trace	0·07	0·04	Trace
Sulphur . . .	0·075	0·075	0·103	0·068
Phosphorus . . .	0·552	0·631	0·592	0·890
Loss on ignition . . .	6·00	8·90	11·20	12·20

This shows the ore exposed in the trench to be comparatively poor in iron, highly siliceous and fairly rich in phosphorus. Sample No. 4 was a specimen of the massive brown limonite taken from the old dumps by Dr. Flett, analysed also at Gartsherrie. The manganese ore was not analysed, but from the appearance of fragments left on the spoil heaps some of it is rich and pure: it occurs only in small pockets in the siliceous ironstone.

The belt of brecciation along which the iron deposits occur is indicated in the accompanying sketch map (Fig. 17). At the extreme north end the first traces on the south side of the watershed are seen at the point marked B, where there is ferruginous breccia and ochreous earth in a dry stream channel. At C and D there are blocks of iron ore. A little farther south, at E, F and G, there are old trial pits and a cross trench apparently made by the miners who worked at the manganese mine. Pieces of spongy brown limonite are scattered about in considerable quantity.

Farther south the course of the vein lies under peat and alluvium on the flat bottom of the valley, and the next indication is on the opposite side of the stream at the north end of the old workings, A. These extend for about 250 yds., and the vein disappears on the north side of the stream Alt na Broighleig. From that point south the vein runs near the bottom of a slope covered with peat and heather, and no trace of it can be seen till the bridge of Leachd is passed. In this valley there are apparently two veins. One is on the east side of the stream, beside the road where, at H, there is a small trial pit, and, a few yards further south, a breccia impregnated with iron ore is visible at the side of the road. The other is on the west side of the valley, and is exposed in two places where lateral streamlets descend the hill side. Large blocks of rusty quartzose ore are visible in the channel, and may be traced to their source about 70 ft. above the main stream. Similar blocks are seen at L where the main stream has cut through the peat which covers the watershed.

Of these exposures of the Leicht vein none can be said to indicate a substantial mass of good ore. In most of them the vein is only a few feet wide and the veinstone is highly quartzose. It may be noted also that no pieces of good haematite or limonite were to be found in the gravel of the streams. Probably the best indications are at E and F, where the vein may be 10 or 15 ft. wide and contains fewer fragments of the country rock.

On the south side of the Leicht pass, the vein emerges again as soon as the sheet of peat which covers the watershed is cut through by the stream. This is the site of the old Allargue workings which have been previously referred to. The ores are similar to those at the manganese mine, but there is very little good ore to be seen in the debris around the mine, and there is no good exposure of the vein. At the bend of the stream south of the mine the brecciated rock that accompanies the vein crosses the channel and cannot be followed further.

In this long belt of brecciated rock, veined and impregnated with the oxides of iron and manganese, it seems quite possible that considerable deposits of useful iron ore may occur; but, if so, this can only be ascertained by a careful and judicious exploration of the vein in its most promising parts. The exposures at present available are quite insufficient for this purpose.

ARNDILLY, CRAIGELLACHIE, BANFFSHIRE.

One-inch Geological Map, Sheet 85. Six-inch Sheet, Banff, 18.

At Arndilly, on the banks of the River Spey, about two miles north of Craigellachie, there are veins of iron ore and manganese ore which have been opened up in places, but no considerable quantities of mineral have been extracted from them. The country rock is a massive white quartzite which is intersected by lines of breccia probably marking faults or planes of movement parallel to the important fault which crosses the Spey about half a mile north of Craigellachie, and has been traced running in a north-west and north direction for several miles. The ores are deposited in the broken quartzite, and are principally haematite, limonite and pyrolusite or psilomelane.

About fifty years ago trials were made in the veins, and in addition to several drifts two small shafts were sunk about 50 yds. apart. One of these is a pit about 20 ft. deep, from the bottom of which an incline has been driven for about 30 ft. The other is a shaft over 20 ft. deep, but at present inaccessible and partly filled up. The rocks removed are mostly quartzite, stained and veined with oxides of iron. Pieces of good haematite and manganese ore can be found among the debris around the drifts or shafts, but no vein of solid ore is visible at the present time. Ferguson* states that four specimens of the ore yielded iron 37.73 per cent., 59.90 per cent., 52.39 per cent. and 36.14 per cent. but so far as can be ascertained iron ore deposits of practical importance have never been revealed in any of the trial workings.

* *Loc. cit.*

CARSPhAIRN IRON ORE VEIN, KIRKCUDBRIGHTSHIRE.

One-inch Geological Map, Sheet 8. Six-inch Sheets, Kirkcudbright, 4 and 8.

This vein occurs in the hills to the south-east of Loch Doon. It is about $3\frac{1}{2}$ miles west of the village of Carsphairn and 9 miles south of Dalmellington. The outcrop is about 1100 feet above the level of Loch Doon. There is no road to the site of the vein, the nearest being at Woodhead lead mines, $2\frac{1}{2}$ miles distant. The vein has been traced for a length of $2\frac{1}{2}$ miles. It has never been worked on a commercial scale, and no ore has been taken out of it and smelted, but on two occasions fairly extensive trials have been made, which have not led to any active developments. This has been due apparently to two causes; the amount of ore proved has always been disappointing, and without large expenditure on providing means of transport there is no way of getting the ore to the blast furnaces.

About 1869 and again in 1876 the Dalmellington Iron Company opened up the vein by a series of cross-cuts and small mines. They took out about 400 tons of haematite, which was of good quality, but it was left on the ground as it would not pay to bring it to Dalmellington. An average analysis of the ore shows iron, 60 per cent.; insoluble, 6 per cent.; phosphorus, 0.28 to 0.30.

In 1901 Messrs. Colville of Motherwell had the vein thoroughly examined by trenches and bores. They have kindly supplied us with particulars, from which the following account is taken. The haematite has been deposited in a fissure running in a north and south direction. At the south end the country rocks are Silurian shales and greywackes, but for about a mile at its northern end the vein intersects the Loch Doon granite. The fissure has a breadth of from 2 to 10 ft. or more, and is in large part occupied by broken masses of the country rock veined with haematite. The greatest depth of the mines driven by the Dalmellington Iron Company was 70 ft. and these proved no great quantity of ore. Messrs. Colville's bores passed in one or two places through 8 ft. of iron ore, but this was by no means solid. Most of the trenches across the outcrop proved nothing but shattered rock stained with iron oxide. There is every reason to believe that a great part of the fissure is barren and that the masses of haematite which occur are small and local.

AUCHINLONGFORD MINE (PENNELL BURN), AYRSHIRE.

One-inch Geological Map, Sheet 23. Six-inch Sheet, Ayrshire, 25 S.W.

This mine is about $3\frac{1}{2}$ miles north-east of Sorn, Ayrshire. It is 7 miles from the nearest blast furnaces, Muirkirk, Auchinleck or Lugar. There is no railway near the mine, and the ore raised was carted to Muirkirk or Lugar. The vein intersects rocks which belong to the base of the Old Red Sandstone of this district, and consist of yellow and red grits, sandstones and shales, with well-marked bands of conglomerate. Many igneous dykes traverse the district; one of them, a decomposed felsite, is said to be crossed by the haematite veins in the old workings. There is some reason to believe that the mine was worked early in the nineteenth century (see p. 4), but in the

years 1872–82 it was the scene of active operations by W. Baird & Co. (Lugar and Muirkirk Iron Works), and by Dalmellington Iron Company, and Coltness Iron Company. The Pennel Burn is the boundary between two properties, and Baird & Co. carried on mining on the west side of the burn, while the Dalmellington and Coltness Companies had a mine east of the burn.

The plan of Auchinlongford No. 1 Pit (Home Office Plans of Abandoned Mines, No. 1436, deposited by Baird & Co.) shows workings on two veins, one bearing east and the other north-west. In the east and west vein the pit was about 280 feet deep, with four levels about 50 feet apart. The second level was the longest, about 900 feet; no ore was taken out in the bottom level. The rich ore deposit was evidently in bunches separated by long stretches of poor ground not worth working. In the north-west vein work was carried on to a distance of 200 feet northwards from the point where the veins crossed, and four levels were driven, of which the upper three are carried out to day-workings on the slope of the valley above the burn.

The Dalmellington Company's workings on the east side of the burn were principally in the east and west vein. A shaft was carried down to a depth of over 200 feet. The principal ore deposit was found between this shaft and the burn; it consisted of haematite in lenticular masses which reached a thickness of 5 or 6 ft. in places, but were often mingled with sandy ore and broken country rock. In the deeper levels no workable ore was got. Mining operations were actively prosecuted in 1873, 1874 and 1875. Before the mine was abandoned the surrounding country seems to have been thoroughly prospected in search of further sources of supply.

GLENBUCK AND POCKMUIR VEINS.

(5 miles west of Douglas, Lanarkshire.)

One-inch Geological Map, Sheet 23. Six-inch Sheet, Lanark, 37 S.W.

In the "Explanation of Sheet 23" (*Mem. Geol. Survey*), p. 49, it is stated that "the extension to the north of the fault which bounds the Glenbuck coal field on its eastern margin contains a considerable quantity of haematite. Though the lode thus formed is in places about 15 ft. wide, the ore is so much mixed up with fragments of chocolate-coloured sandstone that it is doubtful whether the vein can be worked to profit. One of the veins, already mentioned as occurring near the head of the Pockmuir Burn as well as galena and barytes, also contains haematite." The Pockmuir Burn is one of the head-waters of the River Nethan. These veins are indicated on the 1-in. Geological Map, Sheet 23, and have a north or north-west direction. It is not known that they have been worked for iron ore, though it is probable that trials have been made on them more than once.

TEWSGILL HILL, LANARKSHIRE.

One-inch Map, Geological Sheet 15. Six-inch Sheet, Lanark, 43 S.W.

This old mine is situated about $2\frac{1}{2}$ miles north of Crawford, and the same distance east of Abington on the River Clyde. Its position

is marked on the 1-in. Geological Map (Sheet 15). It is at a height of 1800 ft., and the country rocks are Silurian shales and greywackes. Not much is known regarding its history, but in the "Explanation of Sheet 15" (*Mem. Geol. Survey*) it is mentioned, and a note on the field map records that "chocolate-coloured shales and blocks of hæmatite were wrought here for some time."

AUCHENLECK, KIRKCUDBRIGHTSHIRE.

One-inch Map, Geological Sheet 5. Six-inch Sheet, Kirkcudbrightshire, 51 N.E.

At Auchenleck, about 5 miles east of the town of Kirkcudbright a hæmatite vein occurs in the Dalbeattie granite mass. Its course is W. 18° N., and is indicated on the published geological 1-in. map (Sheet 5) by a gold line. In the Explanation of that Sheet (*Mem. Geol. Survey*, 1896, p. 40) it is stated that this is the most important vein of iron ore in that district. For a time it was extensively worked. Hay Cunningham's "Geognostical Account of the Stewartry of Kirkcudbright" (*Highland Society's Transactions*, vol. viii., 1843, p. 730) describes this vein as being mined by a horizontal shaft. "The ore is of red botryoidal hæmatite, and, in drusy cavities fine specimens of this beautiful mineral may be found. The minerals which accompany the iron-ore are ferruginous quartz and sulphate of barytes." "The New Statistical Account of Scotland" (vol. iv., 1845, p. 361) states that from 50 to 70 tons of ore were obtained weekly from this mine, and were being sent chiefly to Birmingham and the neighbourhood. A report by a mining engineer who visited the mine in 1863, when it was working, described the "vein or ore-bearing ground" as 66 ft. wide. At that date, apparently, there was a good deal of ore in sight. We have not ascertained exactly when it was closed down, and there are no published statistics of the output. Recent investigations of this property have not led to any new developments.

AUCHENFAD, KIRKCUDBRIGHTSHIRE.

(4 miles south of Maxwelltown.)

One-inch Map, Geological Sheets 5 and 9. Six-inch Sheet, Kirkcudbright, 34.

Trials for hæmatite have been made in this locality on veins intersecting granite and contact-altered Silurian slates. Their position is indicated by gold lines in the 1-in. Geological Maps (Sheets 5 and 9). In the "Explanation of Sheet 5" (*Mem. Geol. Survey*) the direction of the vein is given as N. 12° W. So far as is known useful ores were not discovered in workable quantity.

CRAIGEND, KIRKCUDBRIGHTSHIRE.

One-inch Map, Geological Sheet 5. Six-inch Sheet, Kirkcudbright, 34.

This vein is about 2 miles west of Auchenfad, and about a mile east-north-east of Loch Arthur. It occurs in the Dalbeattie granite mass, near its northern margin.

On the 1-in. Geological Map, Sheet 5, the position of the vein is marked by a gold line, and its direction is indicated as a little south of west. Apparently this vein has never been systematically worked.

GARLETON HÆMATITE MINE.

One-inch Map, Geological sheet 33. Six-inch sheet, Haddington Old Series, 10 N.W. New Series, 5 S.W.

This mine is situated at the west end of the Garleton Hills, near the Hopetoun Monument, about 2 miles north-west of the town of Haddington. The country rock is trachyte, occurring in thick lava-flows of Lower Carboniferous age. Occupying a well-defined fissure the ore deposit has been traced for nearly 300 yds. in a N.N.W. direction dipping E.N.E. at 80° to 90° , and was last worked by the Coltness Iron Company in the years 1873 to 1876. In 1874, 10,283 tons of brown haematite, worth £6,186 16s., were taken from this mine (*Mineral Statistics of the United Kingdom for 1874*, p. 92). Two shafts were carried down to a depth of nearly 50 fms., and a large quantity of ore was removed, but ultimately the vein was found to thin away both in depth and in horizontal extension, and the working was abandoned. The mining plans show that the fissure was in some places 12 to 16 ft. wide, but in large part filled with a trachytic breccia stained with haematite. The haematite vein was very irregular, in some places 5 or 6 ft. thick, but usually not more than half of this. Sometimes it split up into two veins separated by masses of ferruginous breccia, and the thickest ore bodies were of lenticular shape tapering down at each end. At a depth of 280 ft. the deposit was nowhere found of workable thickness. At the north end of the mine the haematite vein narrowed down to a mere thread. At the south end the vein is directed towards the property of Lord Hopetoun; but the workings were not carried up to the boundary. No workable ore was found in the upper levels at the south end of the mine, but at a depth of 200 to 260 ft. a thickness of about 20 in. of haematite was visible when the workings were stopped.

The mine seems to have been worked to a depth of 120 to 150 ft. before the Coltness Company took it in hand, as their plans show "old workings, inaccessible" in the upper part of the lode.

The nearest railway station is at Haddington, and an excellent road leads from the mine to the railway, downhill all the way.

The vein is exposed to the south of these workings in an old quarry on Phantassie Hill, but no appreciable quantity of iron ore is seen. The brecciated vein stuff is mainly cemented with barytes. This fact limits the possible extension of ore to a very narrow compass.

A bore in the field south of the mine (800 ft. E.N.E. of Blackmains) passed through 2 ft. of haematite at a depth of 111 ft. in the year 1892.

Two partial analyses of the Garleton Hill haematite, by J. Wallace Young, are quoted in *Transactions of the Geological Society of Glasgow* (1869, vol. iii., pp. 373-4).

- (1) Fe_2O_3 89·64 per cent. = Fe 62·75 per cent.
- (2) Fe_2O_3 89·28 per cent. = Fe 62·50 per cent.

TORNAPRESS AND SANACHAN MINES, KISHORN, ROSS-SHIRE.

One-inch Map, Geological Sheet 81. Six-inch Map, Sheet 110.

At two places near the head of Loch Kishorn, on the west coast of Ross-shire, deposits of iron ore were being worked in 1913 and 1914. Tornapress is about a mile and a half north of the upper end of Loch Kishorn. The workings were along a line of post-Cambrian displacement by which the Cambrian dolomitic limestone has been broken and shattered. The Torridon Sandstone is thrust over the Cambrian rocks, and rests on the limestone, the plane of contact dipping steeply to the east. In the shattered limestone below the thrust haematite has been deposited in a series of veins and strings. In 1913 a mine was driven into the hillside, and several hundred tons of iron ore were brought up. They were left in a pile at the side of the stream, and were subsequently carried away during a sudden flood.

The veins seem to have proved irregular and variable, and mining was discontinued in 1914, and never resumed.

At Sanachan, which is half a mile east of the head of Loch Kishorn, the iron ore occurs also in Cambrian limestone, which seems to be a small mass cut off by faults. Here also the haematite was variable in quality, and much mixed with limestone. The results of the mining operations were apparently not very satisfactory, for they soon came to an end.

NOBLEHOUSE HÆMATITE MINE.

One-inch Map, Geological Sheet 24. Six-inch Sheet, Peebles, 5 S.E.

This deposit is found in association with the spilitic lavas of Arenig age on the south side of the Southern Uplands boundary-fault at Noblehouse. These Arenig lavas* come to the surface in the centres of several anticlines running in a N.E.-S.W. direction and are overlain by red mudstones and radiolarian chests. It is in these that the iron ore has been concentrated, although probably derived originally from the underlying lavas. The ferruginous beds are exposed in three streams immediately N.E. of Noblehouse Farm. In connection with the most northerly of these an old pit is shown, but there is no evidence available connecting it with the workings. The second exposure occurs about 230 yds. to the S.W., where the ferruginous mudstones are highly contorted and truncated on the west by a fault. The main outcrop of the ironstone lies 250 yds. still farther S.W., but the ore-bed is not now exposed nor has any material been got here which could be considered to represent in quality the ore actually worked. The mudstones in this exposure show two fairly symmetrical synclines pitching to the N.W. at an angle of about 25°.

The Noblehouse haematite was known as early as the end of the eighteenth century. Mushet,† writing between 1798–1900, describes

* See "Silurian Rocks of Scotland," *Mem. Geol. Surv.*, 1899, pp. 248–9.

† D. Mushet, "Papers on Iron and Steel," 1840, p. 152.

it as "a vein of very considerable thickness"; and gives the following details.

(1) Upper part of vein, dark grey-blush colour, with a whinstone fracture	4 ft. thick ; 37·3 per cent. Fe.
(2) Middle part, reddish-blue	2 ft. , , , 40·2 , , Fe.
(3) Soft greasy ore, of a red colour, with nodules	4 ft. , , , 27 , , Fe.

It is referred to also by Williams, in his "Natural History of the Mineral Kingdom," vol. i., p. 382, where it is described as "a stratum of iron above 20 ft. across where it was opened at the surface near Noblehouse. It is a slaty or shivery iron ore, or ironstone, of a reddish brown colour, and smooth uniform texture in the inside of the masses when broken, and mixed with staining iron earth of the same colour." The ore, according to Williams, was stated to yield "about 25 or 30 per cent. at most." It was worked apparently to a small extent at some period between 1780–90, but very little systematic exploration was done until 1884 when the minerals at Noblehouse were leased by Messrs. Merry and Cuninghame. Inclines were then driven down on the deposit from the surface and the ore worked until 1887. The main workings were in the most southerly of the exposures mentioned above. Two inclines, apparently in adjacent troughs, were driven north-east into the stream-bank and the ore extracted on either side of these. The inclination was 20–25°. As the workings travelled outwards on either side of the inclines the ore rapidly deteriorated. From the description given of the pavement it may have been formed of the Arenig lavas which were in all likelihood the original source of the iron. The ore was carted to Lamancha and thence taken by rail to Carnbroe.

At the second exposure mentioned above, the ore was quarried and found to be manganiferous in patches. A mine driven a short way in the right bank of the stream here found no good ore.

Nothing has been done since the mine was abandoned in 1887–8. The troughs worked appear to have been nearly exhausted, but there would seem to be a good chance of others occurring in the vicinity, although no large body of ore could be expected.

The output from the mine during the years 1884–6 was as follows :—

1884	2,218 tons
1885	3,264 , ,
1886	803 , ,

The value of the ore was 10s. per ton at the mine, and the percentage of iron estimated at 50.

Two analyses of ironstone from Noblehouse are given below, both kindly communicated by the Shotts Iron Co. Ltd.

	No. 1.		No. 2.	
	Dried.	As Drawn.	Dried.	As Drawn.
Fe ₂ O ₃	53.20	52.47	42.80	42.29
FeO	0.72	0.71	1.44	1.42
FeS ₂	...	...	0.02	0.02
MnO	0.15	0.14	0.30	0.29
SiO ₂	33.75	33.29	44.00	43.48
Al ₂ O ₃	8.07	7.96	5.37	5.30
CaO	0.65	0.64	1.70	1.68
MgO	0.86	0.85	0.73	0.72
P ₂ O ₅	0.33	0.32	1.13	1.11
Combined water	2.25	2.22	2.50	2.47
Moisture	...	1.36	...	1.18
Total	99.98	99.96	99.99	99.96
Iron	37.80	37.28	31.08	30.71
Sulphur	...	...	0.01	0.01
Phosphorus	0.14	0.13	0.49	0.48

Analysis No. 2 is of material collected by the writer in July 1917. It is doubtful if these analyses represent as good a quality of stone as that actually worked by Messrs. Merry and Cunningham.

GARRON POINT, STONEHAVEN.

One-inch Map, Geological Sheet 67. Six-inch Sheet, Kincardine, 12 S.E.

The Cambrian beds which contain the ironstones form here a narrow belt along the southern margin of the Highland (Dalradian) schists, the junction between the two being an overthrust fault,* they are well exposed on the coast between Craigieven Bay and Garron Point: they consist mainly of a suite of pillow lavas, but associated with these occur lenticular beds of fine-grained siliceous ironstone and bands of black shale and jasper.† The ironstone beds range from a few inches up to 6 ft. in thickness. Several of them can be traced for a considerable distance, but vary very much in thickness from point to point. It is their number rather than their individual persistence as workable subjects that attracts attention. They are fine-grained, cherty shales, rich in iron oxides: the oxide is either magnetite or hæmatite set in a siliceous groundmass. Pyrites is locally present. The breadth of the outcrop is only about 100 yds.: its length approximately half a mile. There is little probability that these beds will be worked at Craigieven Bay, but it is possible that similar iron ore deposits may occur in the narrow strip of Cambrian rocks that lies north of the Highland boundary fault.

Several analyses, the results of which are given below, have been kindly made by Messrs. Wm. Dixon and Co. Ltd., at their Calder

* R. Campbell, "The Geology of South-Eastern Kincardineshire," *Trans. Roy. Soc. Edin.*, vol. xlvi., 1913, p. 923.

† Heddle, M. F., "The Geognosy of Caithness," *Mineralogical Magazine*, vol. iv., 1880, p. 20.

Ironworks (Table 1), and by Messrs. D. Colville & Sons Ltd. (Table 2) at Glengarnock. They were made from specimens collected by the Geological Survey.

Analyses of Ironstones, Craigieven Bay to Garron Point.

TABLE I.—(*Wm. Dixon and Co. Ltd.*)

No. of Specimen.	2.	3.	6.	7.
	Per cent.	Per cent.	Per cent.	Per cent.
Iron	35·56	43·96	40·32	33·04
Insoluble	39·00	27·00	32·70	45·50
Silica	34·30	24·40	31·80	42·40
Phosphorus	0·68	1·32	0·766	0·541
Carbonate of lime	1·80	4·82	2·68	4·70
Manganese	0·48	0·64	0·24	0·32
Sulphur	0·120	0·137	traces	0·041
Alumina	4·70	2·60	0·90	3·10

TABLE II.—(*D. Colville and Sons Ltd.*)

No. of Specimen.	2.	3.	6.	7.
	Per cent.	Per cent.	Per cent.	Per cent.
Iron	34·27	33·39	30·42	34·65
Silica	34·90	29·50	46·70	41·60
Loss on ignition	2·30	6·50	1·00	1·80

ACHAVARASDALE, REAY, CAITHNESS.

One-inch Geological Sheet, Scotland, 115. Six-inch Sheets, Caithness, 4, 10.

This mine is situated about nine miles west of Thurso, and a mile from the north coast of Scotland. It is on the Sandside estate, and was started in 1870. Miners were obtained from Newcastle and work was carried on till 1873 when the mine closed down. About 150 tons of haematite were raised and shipped to Newcastle. The Ordnance Survey Sheets indicate the existence of three shafts or openings on the east and north of Achavarasdale Lodge. The principal vein runs in a direction N. 27° E. as shown on the published one-inch geological sheet. Its length is 400 to 600 yds.; at its south end it intersects granite, but at the north end the country rock is Old Red Sandstone.

Professor Heddle, who visited the district shortly after the workings ceased, says that "three pits, at an extreme distance from one another of 300 yds., have been sunk upon the ore, to a trifling depth. So far as exposed, both rock and ore are in a state of complete smash." He considers the deposit to be a bed, but all the circumstances indicate clearly that it is a vein which follows a line of crushing or faulting; and this is the opinion of Dr. Peach, who has visited the exposures. Heddle quoted two analyses of the haemátite or goethite, showing 88 to 89 per cent. of ferric oxide, but it is clear that much of the deposit is very poor in iron and consists principally of broken country rock, stained and impregnated with iron oxides.

HÆMATITE VEINS OF HOY, ORKNÉY.

Veins of haematite and of manganese ore (psilomelane) occur in the island of Hoy, Orkney, and have yielded many fine specimens

though they have never been worked to profit. About the year 1765 mining operations were carried on near the Kirk of Hoy on a vein of hæmatite. Professor Fleming says, "These veins have been well known ever since the establishment of the Carron Iron Works. The proprietors of that concern ordered them to be explored, at a period when they did not expect to find a sufficient supply of ores in their own neighbourhood. No veins of workable breadth have hitherto been discovered."* Fleming's statements are confirmed by the appearance of "Orkney ore" in Mushet's list of the iron ores that had been smelted at Carron (see p. 7). The prospects were apparently not encouraging, as no further attempts have been made to work these deposits. Professor Forster Heddle, whose father was proprietor of the island, gives a detailed account of the iron and manganese minerals of these veins, without suggesting that there is any chance that they may ultimately prove workable.

THE SANDLODGE MINE, SHETLAND.

Maps, One-inch Sheet, 126. Six-inch Sheet, Shetland, 62.

On the east side of the mainland of Shetland there is a narrow strip of Old Red Sandstone, which rests unconformably in the ancient schists and gneisses that make the greater part of the west coast and northern half of the island. In places these Old Red Sandstone rocks, mainly conglomerates, sandstones and flags, are faulted down to east against the older crystalline series by powerful boundary faults.

Deposits of copper pyrites, siderite, hæmatite and limonite occur in association with these faults in several places south of Lerwick. Trials have been made at Levenwick and Cuningsburgh, 4 miles from Lerwick, and copper pyrites was recently worked at a small mine near Setter. The principal ore deposit of this district, however, is situated at Sandlodge, and has been worked at several periods since the end of the eighteenth century. Within the last two years attention has again been directed to the possibilities of this mine, which had been abandoned and flooded since 1881, and further developments may take place. The proprietor of the estate is Mr. Bruce of Sumburgh, Shetland.

The Sandlodge mine is on the coast about 14 miles south of Lerwick, with which the district is connected by a good road. A small pier has been erected near the mine. Shetland has not yet been surveyed by the Geological Survey, but on the Ordnance Survey Six-inch Sheet (Shetland 62) the position of three shafts is indicated on a line bearing N. 10° E. on the east side of Sandlodge House and immediately adjacent to it.

A few years before 1800, a party of Welsh miners worked a vein of copper pyrites for a time. When Professor Jameson visited Sandlodge operations were being carried on on a small scale (Jameson, *Mineralogy of the Scottish Islands*, 1800, vol. ii., p. 198).

* Fleming, John, "Mineralogy of Orkney," issued as an appendix to John Shirreff's *General View of the Agriculture of the Shetland Islands*, Edinburgh 1814, p. 111. Heddle, M. F., "The Geognosy of the Orkney Islands," *Mineralogical Magazine*, vol. iii., 1879, p. 233.

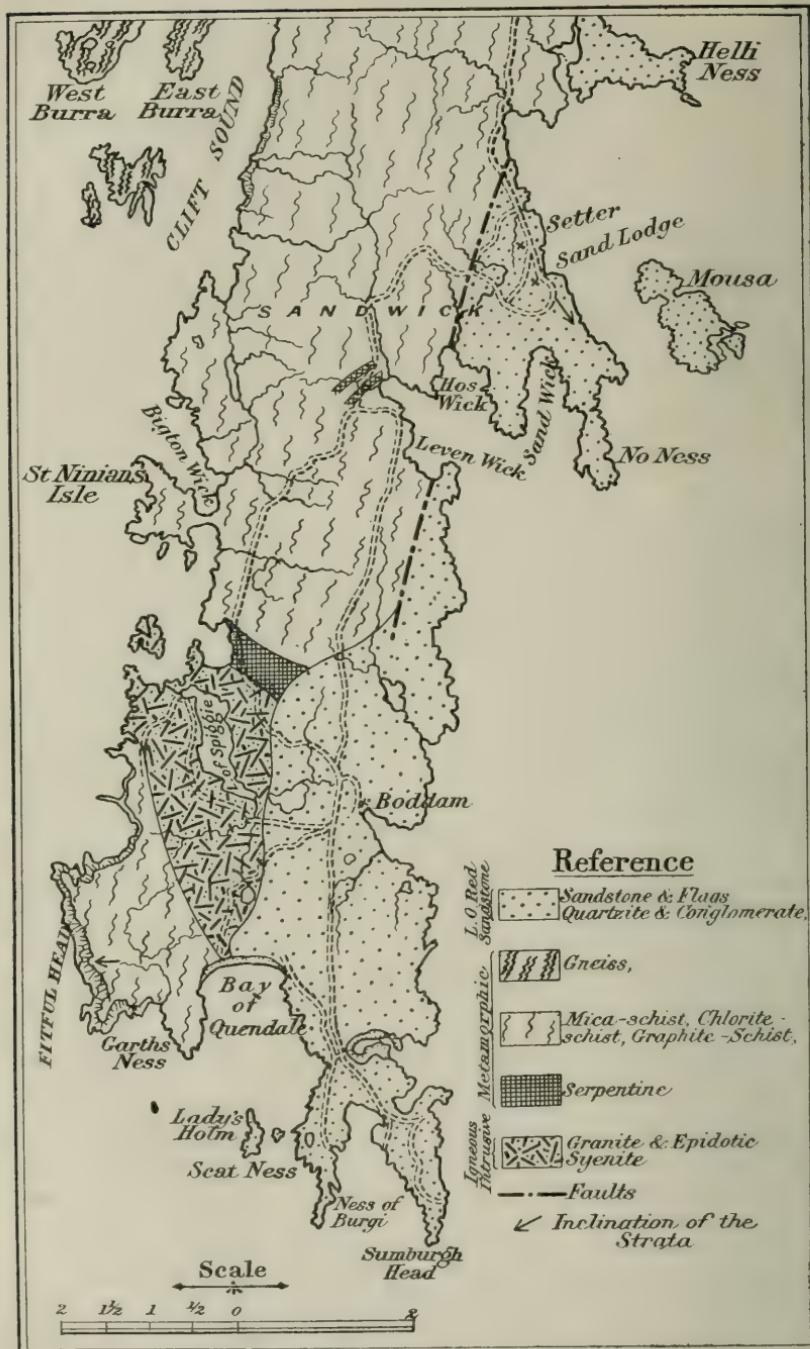


FIG. 18.—Geological Map of the South of Shetland.

Patrick Neill was there in 1803, and found the miners still at work, but before 1806 mining had been discontinued (Patrick Neill, *A Tour through some of the Islands of Orkney and Shetland*, 1806, pp. 169–171). He states that many years before his visit the mine had been worked by an English company as an iron mine, and proved unsuccessful. The discovery of copper ore in the vein had led to the resumption of operations shortly before Neill's visit. In June 1808, Professor Fleming found the mines abandoned and full of water (John Shirreff, *General View of the Shetland Islands*, 1817, p. 129). Any further workings were on a small scale till about 1873, when the mines were reopened by Mr. John Walker. The spongy brown iron oxides which occur in the upper part of the vein were now extracted and sold for use in gas works as a desulphurising agent, and the richer copper ores were separately treated. In 1881 the mine was transferred to the Sumburgh Mining Company but soon closed down. Since that date no serious mining operations have been carried on. It is estimated that Mr. Walker raised about 10,000 tons of iron and copper ore. In 1880 the Sandlodge mine produced 1995 tons of copper ore, worth £5,814, and 396 tons of gossan or iron ore, worth £344, 15s.; the figures for 1878 being, copper ore, 708 tons, worth £1,770, and haematite, 1241 tons, worth £1,550 (*Mineral Statistics of the United Kingdom* for 1878 and 1880).

The upper portion of the vein consists of weathered spongy brown haematite or limonite, with patches or nests of copper-bearing minerals, principally native copper, malachite and chrysocolla. Apparently the percentage of copper in the lode was pretty variable. At a depth of about 100 ft. these oxidised ores gave place to a white, pink, or greyish stone, consisting of crystalline siderite (with calcite and dolomite) and disseminated copper pyrites. It is believed that most of the limonite has been taken out above the 100-foot level. The siderite ore was crushed and the copper pyrites extracted, but no attempt was made to utilise the gangue as an iron ore. Analyses of this ore show that it contains from 5 per cent. to 7 per cent. of copper. Samples of the white or flesh-coloured spongy siderite contained 32 per cent. iron in the moist sample, or 40 per cent. when calcined. We have seen numerous analyses of the minerals of this lode, but as most of the specimens analysed have merely been fragments taken from the dumps of the old mine, they cannot be regarded as reliable indications of its value as an iron ore. The presence of copper and of considerable quantities of sulphur places it in a special class requiring distinct treatment, and it may prove possible, after extracting the copper, to use the residue as an iron ore. It seems clear that siderite is not the only constituent of the gangue, but that calcite, dolomite and quartz are also present, (Heddle, *Mineralogy of Scotland*, vol. i., p. 141).

Mr. R. W. Dron, who visited this mine in 1907 ("Iron and Copper Mining in Shetland," *Trans. Geol. Soc. Glasgow*, vol. xiii., 1908, p. 165), states that the lode was reported to be 9 or 10 ft. wide. The west shaft was sunk on the incline to a depth of 180 ft. The other shaft is vertical and cuts the lode at 240 ft.; from the bottom of this shaft workings were extended downwards in the lode for a further depth of 60 ft., and levels were driven northwards for a distance of 220 ft., and southward for a distance of 190 ft. Dr. Peach

informs us that in places the old workings, which he inspected in 1881, were 26 ft. wide, and the lode is of great size.

This lode is evidently an important one, and it is not probable that it is exhausted, but from the presence of both copper and iron minerals it belongs to a class distinct from any other iron lode that has been worked in Scotland. Special metallurgical problems are involved in the treatment of ores of this class, but considering the extensive employment of cupriferous pyrites as sources of iron at the present day, we may be prepared to regard the Sandlodge mine as presenting distinct possibilities of future development.

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